Technical Memorandum:

Delta Risk Management Strategy (DRMS) Phase 1

Topical Area:

Economic Consequences

Draft 2

Prepared by:
URS Corporation/Jack R. Benjamin & Associates, Inc.

Prepared for:
California Department of Water Resources (DWR)

June 15, 2007

URS

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Subject: Delta Risk Management Strategy
Phase 1 Draft 2 Technical Memorandum –Economic Consequences

Dear Mr. Svetich:

Please find herewith a copy of the subject technical memorandum. Members of the Steering Committee's Technical Advisory Committee and agency staff have reviewed the draft technical memorandum, and this second draft addresses their comments.

This technical memorandum was prepared by Wendy Illingworth (Economic Insights), David Mitchell (M-Cubed), Roger Mann (RMEcon), and Steve Hatchett (Western Resource Economics). This technical memorandum was reviewed by Dr. Said Salah-Mars DRMS (URS), and Marty McCann (JBA), and Loren Bottorff. Internal peer review was provided in accordance with URS' quality assurance program, as outlined in the (DRMS) project management plan.

Sincerely,

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Topical Area: Economic Consequences

Preamble

The Delta Risk Management Strategy (DRMS) project was authorized by DWR to perform a risk analysis of the Delta and Suisun Marsh (Phase 1) and to develop a set of improvement strategies to manage those risks (Phase 2) in response to Assembly Bill 1200 (Laird, Chaptered, September 2005). The Technical Memorandum (TM), is one of 12 TMs (2 topics are presented in one TM: hydrodynamics and water management) prepared for topical areas for Phase 1 of the DRMS project. The topical areas covered in the Phase 1 Risk Analysis include:

1. Geomorphology of the Delta and Suisun Marsh
2. Subsidence of the Delta and Suisun Marsh
3. Seismic Hazards of the Delta and Suisun Marsh
4. Global Warming Effects in the Delta and Suisun Marsh
5. Flood Hazard of the Delta and Suisun Marsh
6. Wind Wave Action of the Delta and Suisun Marsh
7. Levee Vulnerability of the Delta and Suisun Marsh
8. Emergency Response and Repair of the Delta and Suisun Marsh Levees
9. Hydrodynamics of the Delta and Suisun Marsh
10. Water Management and Operation of the Delta and Suisun Marsh
11. Ecological Impacts of the Delta and Suisun Marsh
12. Impact to Infrastructure of the Delta and Suisun Marsh
13. Economic Impacts of the Delta and Suisun Marsh

Note that the Hydrodynamics and Water Quality topical area was combined with the Water Management and Operations topical area because they needed to be considered together in developing the model of levee breach water impacts for the risk analysis. The resulting team is the Water Analysis Module (WAM) Team and this TM is the Water Analysis Module TM.

The work product described in these TMs will be used to develop the integrated risk analysis of the Delta and Suisun Marsh. The results of the integrated risk analysis will be presented in a technical report referred to as:

14. Risk Analysis – Report

The first draft of this report was made available to the DRMS Steering Committee in April 2007.

Assembly Bill 1200 amends Section 139.2 of the Water Code, to read, "The department shall evaluate the potential impacts on water supplies derived from the Sacramento-San Joaquin Delta based on 50-, 100-, and 200-year projections for each of the following possible impacts on the delta:

1. Subsidence.
2. Earthquakes.
3. Floods.
4. Changes in precipitation, temperature, and ocean levels.
5. A combination of the impacts specified in paragraphs (1) to (4) inclusive."

In addition, Section 139.4 was amended to read: (a) The Department and the Department of Fish and Game shall determine the principal options for the delta. (b) The Department shall evaluate and comparatively rate each option determined in subdivision (a) for its ability to do the following:

1. Prevent the disruption of water supplies derived from the Sacramento-San Joaquin Delta.
2. Improve the quality of drinking water supplies derived from the delta.
3. Reduce the amount of salts contained in delta water and delivered to, and often retained in, our agricultural areas.
4. Maintain Delta water quality for Delta users.
5. Assist in preserving Delta lands.
6. Protect water rights of the "area of origin" and protect the environments of the Sacramento- San Joaquin river systems.
7. Protect highways, utility facilities, and other infrastructure located within the delta.
8. Preserve, protect, and improve Delta levees…."

In meeting the requirements of AB 1200, the DRMS project is divided into two parts. Phase 1 involves the development and implementation of a risk analysis to evaluate the impacts to the Delta of various stressing events. In Phase 2 of the project, risk reduction and risk management strategies for long-term management of the Delta will be developed.

Definitions and Assumptions

During the Phase 1 study, the DRMS project team developed various predictive models of future stressing events and their consequences. These events and their consequences have been estimated using engineering and scientific tools readily available or based on a broad and current consensus among practitioners. Such events include the likely occurrence of future earthquakes of varying magnitude in the region, future rates of subsidence given continued farming practices, the likely magnitude and frequency of storm events, the potential effects of global warming (sea level rise, climate change, and temperature change) and their effects on the environment. Using the current state of knowledge, estimates of the likelihood of these events occurring can be made for the 50-, 100-, and 200-year projections with some confidence.

While estimating the likelihood of stressing events can generally be done using current technologies, estimating the consequences of these stressing events at future times is somewhat more difficult. Obviously, over the next 50, 100, and 200 years, the Delta will undergo changes that will affect what impact the stressing events will have. To assess those consequences, some assumptions about the future "look" of the Delta must be established.

To address the challenge of predicting impacts under changing conditions, DRMS adopted the approach of evaluating impacts absent changes in the Delta as a baseline.

This approach is referred to as the “business-as-usual” (BAU) scenario. Defining a business-as-usual Delta is required, since one of the objectives of this work is to estimate whether ‘business-as-usual’ is sustainable for the foreseeable future. Obviously changes from this baseline condition can occur; however, as a basis of comparison for risks and risk reduction measures, the BAU scenario serves as a consistent standard rather than as a “prediction of the future” and relies on existing agreements, policies, and practices to the extent possible.

In some cases, there are instances where procedures and policies may not exist to define standard emergency response procedure during a major (unprecedented) stressing event in the Delta or restoration guidelines after such a major event. In these cases, prioritization of action will be based on: (1) existing and expected future response resources, and (2) highest value recovery/restoration given available resources.

This study relies solely on available data. Because of the limited time to complete this work, no investigation or research were to be conducted to supplement the state of knowledge.

Perspective

The analysis results presented in this technical memorandum do not represent the full estimate of risk for the topic presented herein. The subject and results are expressed whenever possible in probabilistic terms to characterize the uncertainties and the random nature of the parameters that control the subject under consideration. The results are the expression of either the probable outcome of the hazards (earthquake, floods, climate change, subsidence, wind waves, and sunny day failures) or the conditional probability of the subject outcome (levee failures, emergency response, water management, hydrodynamic response of the Delta and Suisun Marsh, ecosystem response, and economic impacts) given the stressing events.

A full characterization of risk is presented in the Risk Analysis Report. In that report, the integration of the probable initiating events, the conditional probable response of the Delta levee system, and the expected probable consequences are integrated in the risk analysis module to develop a complete assessment of risk to the Delta and Suisun Marsh.

Consequently, the subject areas of the technical memoranda should be viewed as pieces contributing to the total risk, and their outcomes represent the input to the risk analysis module.

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List of Acronyms and Abbreviations

AADT	average annual daily traffic
ACWD	Alameda County Water District
AF	acre-feet
AVEK	Antelope Valley- East Kern Water District
BNSF	Burlington-Northern and Santa Fe Railroad
CA Chapter	California Chapter of the American Society of Farm Managers and Rural Appraisers
Caltrans	California Department of Transportation
CCWD	Contra Costa Water District
CIRIS	California Interregional Intermodal System
CVP	Central Valley Project
CVPM	Central Valley Production Model
Delta	Sacramento-San Joaquin River Delta
DPC	Delta Protection Commission
DRMS	Delta Risk Management Study
DWR	Department of Water Resources
EBMUD	East Bay Municipal Utility District
ECCID	East Contra Costa County Irrigation District
ESRI	A GIS software consultancy
FAO	Food and Agriculture Organization
FEMA	Federal Emergency Management Agency
GIS	Geographic Information System
HAZUS	FEMA-developed software for estimating the effects of disaster
ID	Irrigation District
IMPLAN	A proprietary Land Management Planning software and database package
InfoUSA	A company providing a proprietary database of business information
KMEP	Kinder Morgan Energy Partners

LBNL	Lawrence Berkeley National Laboratory
LCPSIM	Least Cost Planning Simulation Model
mcf	thousand cubic feet
MHHW	Mean Higher High Water
MWDSC	Metropolitan Water District of Southern California
PG&E	Pacific Gas and Electric Company
RD	Reclamation District
RPCs	regional purchase coefficients
REDARS	Risks from Earthquake Damage to Roadway System
SCVWD	Santa Clara Valley Water District
SFPUC	San Francisco Public Utilities Commission
SOD	South of Delta
SWP	State Water Project
TAF	thousand acre-feet
TM	technical memorandum
USACE	United States Army Corps of Engineers
USDC	U.S. Department of Commerce
USFWS	U.S. Fish and Wildlife Service
WAM	Water Analysis Module
WECC	Western Electric Coordinating Council
WD	Water District
Zone 7	Alameda County Flood Control and Water Conservation District – Zone 7

1.0 Introduction

1.1 Background

The Sacramento-San Joaquin River Delta (Delta) includes assets and activities that are important to the State of California's economy. A number of beneficial economic activities take place within the Delta, including residential, business, agricultural, and recreational services. The levees in the Delta also protect parts of several California cities including Sacramento, Stockton, and West Sacramento. In addition to these services, infrastructure of statewide importance is located within the Delta. These infrastructure assets provide services such as water, electricity, natural gas, petroleum products and transportation services to the state as a whole. Finally, the Delta provides important environmental services.

1.2 Purpose and Scope

This technical memorandum (TM) describes the approaches taken to estimate the economic consequences of lost use of facilities and resources caused by levee failures in the Delta. This report provides documentation for the modeling approach taken for the risk model, and does not present any results related to specific scenarios, nor provide input for policy considerations.

This analysis does not include all economic costs. Damage costs, repair and restoration expenses are covered elsewhere. The scope of this economic analysis is focused on the economic effects of lost use: the inability to use buildings, land, facilities, infrastructure, water, and any other resources caused by or damaged by failure of levees in the Delta. Because the flooding zones do not end at the Legal Delta boundaries, this area is larger than the Legal Delta, and is described in this TM as the Delta Protected Area. The scope of the study area for flooding is the analysis zones shown on Figures 1 through 3. In addition, areas of the state outside the flooding study area may be impacted through loss of infrastructure in the Delta Protected Area, or because of reduced Delta water quality that result from the levee failures. There are also potential additional out-of-state consequences, but these are not addressed in this TM.

The scope of economic effects includes economic costs and economic impacts. Economic costs are the net costs to the state economy that result from levee failure. They do not take into account who bears the costs. All economic costs are generally additive. Economic costs can not be added to economic impacts; they are different measures.

Economic impacts include a variety of other economic measures. Employment, value of output, wage and salary income and value added are reported here. These measures are not additive with each other, and they should not be added to economic costs. Value added is the sum of wages and salaries, proprietor's incomes, other property income, and indirect business taxes.

The potential sources of economic consequences are numerous, and not well understood. This study brings together a broad range of identified economic consequences, many of which have not previously been fully described, and certainly not assembled in one

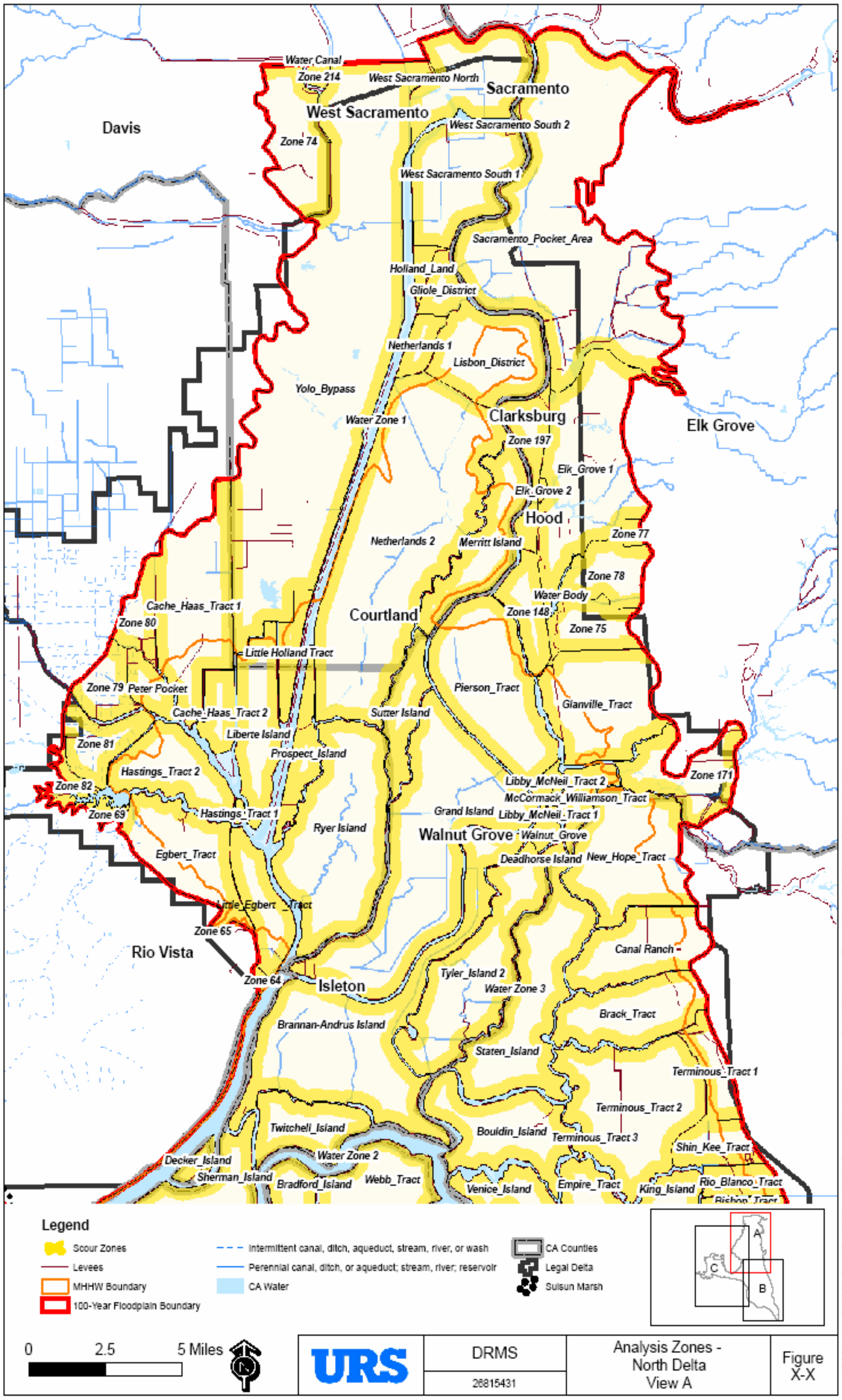

Figure 1 Delta Protected Area Analysis Zones – North Delta

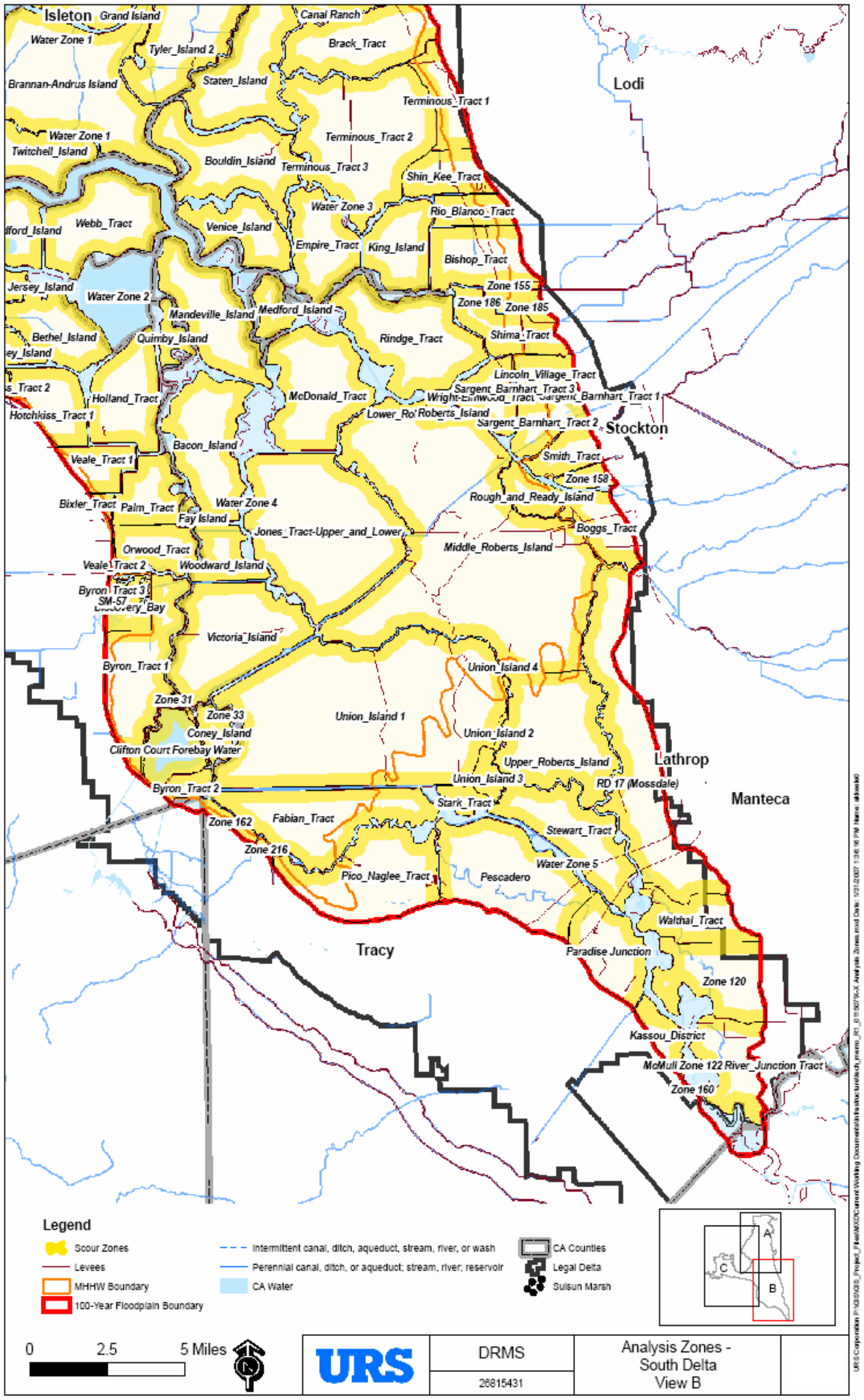

Figure 2 Delta Protected Area Analysis Zones – South Delta

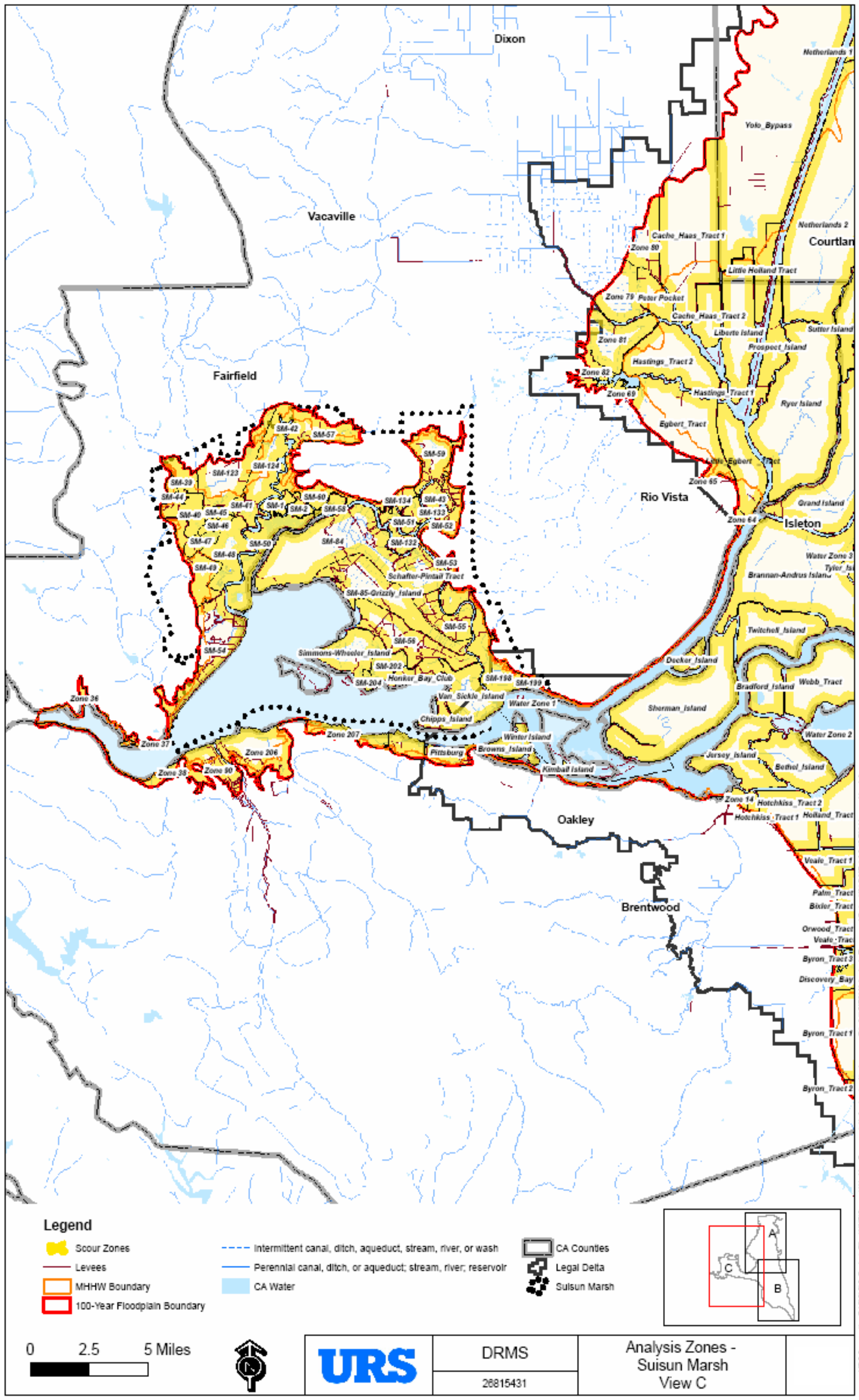

Figure 3 Delta Protected Area Analysis Zones – Suisun Marsh and West

analysis. In addition, it utilizes a high level of spatial detail in the Delta area to enable analysis of combinations of flooded areas.

The guiding principal of this analysis is the risk analysis should be based on the continuance of current trends. The assumption is that current planning and policies will guide how organizations will most likely respond to levee failure.

A working premise of the Delta Risk Management Study (DRMS) project is the need to rely primarily on existing models, data, and analyses. In some cases the needed data or models were not available, and so new data were obtained or assumptions were required. These assumptions were made using best available judgment, but could not always be checked against appropriate data. Often, data that might be used to support the assumptions were not readily available.

Many of the sectors investigated include agencies and businesses that have assisted us by providing data and analysis on which we have relied. In a few cases agencies or businesses have been unable or unwilling to provide information, and the team has been required to make assumptions or approximations. Of necessity, these instances weaken the accuracy of the analysis.

1.3 Organization of this Technical Memorandum

The remainder of this TM is organized into three sections:

Section 2: Approaches Taken – This section of the TM discusses the approaches taken to estimate the potential economic costs and impacts of levee failure. Further details of the analysis can be found in the attached appendices. This section is further subdivided according to the following general types of direct effects:

In-Delta Costs and Impacts
These include:

- Lost use of structures used by residents, businesses and public services in the Delta (for example, loss of use of homes, lost use of business places and loss of business incomes)
- In-Delta agricultural losses
- In-Delta recreation losses

Disruption to Water Supplies
This section addresses the potential cost for disruption of water supplies that transit the Delta, including water delivered by the State Water Project (SWP), Central Valley Project (CVP) and the conveyance facilities crossing the Delta (Mokelumne Aqueduct). These are discussed in two subsections: consequences to agriculture and consequences to urban users.

Infrastructure of Statewide Importance
This section addresses the potential costs from the loss of infrastructure in the Delta that serves a wider area than just the Delta. For example, electric utilities own local assets in the Delta (distribution lines) and also assets of statewide importance (transmission lines). Impacts resulting from loss of infrastructure located in the Delta that provide services to the state as a whole. This section explores only the consequences of lost use of the assets,

and once again, does not include the effect of repair or replacement of the assets themselves.

Changed Reservoir Operations
This section discusses the consequences resulting from changed operation of reservoirs, including the loss of hydroelectric generation and recreation opportunities.

Economic Impacts
In addition to measuring economic costs above, the analysis also estimates the economic impacts of the disruption. Economic impacts are measured by value of output, wages and salaries, employment, and value added. Value added consists of wages and salaries, proprietor's income, other property income, and certain business taxes.

The economic costs reported in this TM do not include the economic or financial costs of repairing or replacing lost assets.

The scope of the lost use analysis does not include these certain types of payments, actions, and economic effects that are often taken in response to flooding:

1. The compensation provided by private insurance payments, disaster payments or other emergency social assistance. To the extent that this money comes from outside the state, the inflow of money would be beneficial. To the extent that this money comes from within the state – through State government payments or business and householder budgets, there is no benefit to the state, just transfer payments between state residents. We do not have any way of estimating the shares of money for rebuilding from inside and outside the state.
2. The positive economic effects of reconstruction on businesses and local or state economies.
3. The effects of flooding and reconstruction on prices of goods and services required for reconstruction. These price effects may be positive for some persons.

Section 3: Uncertainty in the Estimates – This section describes the limitations of the work presented in this technical memorandum, and explores the sources and types of uncertainty.

Section 4: References – This section lists the references that were used to prepare this technical memorandum.

Appendices – The following supporting appendices are also included:

Appendix A: Lost Use of Residential and Business Structures and Public Services

Appendix B: Impacts to Crop Production Based on Flooding of Agricultural Lands

Appendix C: Delta Island Recreation

Appendix D: South of Delta Agricultural Water Users

Appendix E: Urban Water Users

Appendix F: Other Infrastructure of Statewide Importance

Appendix G: Economic Impacts

These appendices provide a great deal of detailed supporting data that are too voluminous to be included in the body of this report.

2.0 Approaches Taken

2.1 In-Delta Losses

This section describes the economic costs of losses associated with flooding of activities in the Delta and surrounding flood zone. To allow for the estimation of costs and damages under a number of levee breach scenarios, the Delta was divided into analysis zones. Each of the zones was defined as an area that could flood independently of other zones as the result of a single levee break. Thus the zones are largely defined by the existence of levees or high ground that divides one analysis zone from the others. Some zones were assigned island names, and others were assigned identifying numbers so that they could be defined uniquely.

2.1.1 Lost Use of Structure and Services

This section counts economic costs and impacts associated with lost use of residences, other living places, business space and public building in the Delta and the surrounding area flooded through Delta levee failure. Use is lost during any flood, and lost use continues until the space and facilities can be used again.

Residential Structures

California Department of Water Resources (DWR) used 1990 census data to estimate the population of Delta islands in that year at about 22,300 persons. At the same, the populations of Sacramento and Stockton were 369,000 and 211,000, respectively. The 2000 census data summarized by DWR found that population of the same Delta Islands had increased to about 26,000 persons and 11,000 households (Hambright 2006). HAZUS data for this same area show 18,270 single-family residential structures in the region and 18,900 total residential housing buildings in the 100-year floodplain. In addition, about 8,900 structures are located in the West Sacramento portion of the 100-year floodplain, and 5,000 more in the 100-year floodplain in the Netherlands, in Reclamation District (RD) 17 (Mossdale), the Moore Tract, and over water. The largest numbers of residential structures in the study area are in the outlying areas near the Sacramento pocket area (Zone 196, 66,000 in the 100-year floodplain), near Stockton (8,000 in Zones 157 to 159), along the I-5 corridor south of Sacramento (Zone 76, 3,500), and about 6,000 more spread about the outer zones. Also, there are about 700 residential structures in the Suisun Marsh that are in the 100-year floodplain in the study area.

In total there are about 116,000 residential structures in the 100-year floodplain of the study area. In contrast, there are fewer than 8,000 residential structures below the mean higher-high water (MHHW) line. Most of these are located on the interior Delta islands; Bethel, Brannan-Andrus and Wright-Elmwood Tract account for about half of these.

DWR has provided forecasts for population and households of Delta islands for 2030. Population is projected to increase from about 26,000 to 67,000 and households will increase from 11,000 to 27,000. A large share of this growth is associated with westward expansion of the Stockton metropolitan area onto Bishop, Sargent Barnhart, Stewart and Shima Tracts.

The residential lost use analysis counts costs and impacts to people living in the areas at the time of the flood event. The economic methodology is based on Federal Emergency Management Agency (FEMA 2005). The FEMA method for estimating displacement costs consists of a one time cost of $500 per household if flooded, plus $500 per month per household, plus a monthly cost based on local rental rates. Local rental rates are from U.S. Department of Commerce (USDC 2003). The monthly rental cost is $747 per household. HAZUS residential structure data were used to estimate current occupied households. For purposes of this analysis, the number of households that were assumed to be associated with each structure type are as follows:

Single Family Dwelling	1
Manufactured Housing	1
Duplex	2
Triplex – Quads	3.5
Multi-Dwellings – 5 to 9 units	7
Multi-Dwellings - 10 to 19 units	14
Multi-Dwellings - 20 to 49 units	30
Multi-Dwellings - 50+ units	50

Occupied household estimates were compared to data developed by DWR using Geographic Information Systems (GIS) mapping and the 2000 census data on occupied households and population in households (Hambright 2006). Comparison of these independent estimates is provided in Appendix A. These data suggest that the number of residential structures in the Delta exceed occupied households by about 65 percent. Therefore, the residential housing data from HAZUS are divided by 1.65 to obtain an estimate of occupied housing needed for the FEMA method.

Some of the population in the analysis zones does not live in households. These people may live at institutions, in dormitories, or in work-provided housing. The HAZUS data provides the number of institutional dormitories and nursing homes. If either of these housing types is present in an analysis zone, then the difference between total population and household population, from the 2000 census is calculated. This is the estimate of non-household population. The FEMA method assumes that the cost of housing these people in emergency shelters is $85 per person per day.

2030 data developed for the California Water Plan were used to adjust the HAZUS data for Delta islands to 2030 conditions. For other analysis zones, population estimates by county for 2004 and 2030 from Woods and Poole Economics (2006) were used to develop growth factors which were applied to the HAZUS residential structure estimates by analysis zone. Details about the population and housing data by analysis zone are provided in Appendix A.

Results by analysis zone are provided in Appendix A. Under the 2005 MHHW flood condition the daily residential displacement cost for all analysis zones is $244,000. For the 100-year floodplain, daily costs for all zones would be $3.4 million. These costs do not include the one-time costs of $500 per household which would be spread over the entire duration of lost use. For all of the analysis zones, these costs total about $2.14 million under the MHHW flood condition and $33 million for the 100-year condition.

Under the 2030 MHHW condition the daily residential displacement cost for all analysis zones is $380,000. For the 100-year floodplain, daily costs for all zones would be $8.5 million. For all of the analysis zones, the one-time costs total about $3.6 million under the MHHW condition and $91.3 million for the 100-year condition.

It should be stressed that these are the displacement costs per day if all of the population protected by Delta levees were displaced. It is extremely unlikely that any scenario would result in such a widespread displacement of people. Rather, the costs for any given scenario should be developed by summing the losses for each analysis zone or part of analysis zone that is impacted by the scenario.

Businesses

The study area includes about 15,900 businesses that are counted by the ESRI (Post, Buckley, Schuh & Jernigan, Inc.) database. A summary of the study area economy in terms of value of sales and employment by sector is provided in Table 1. As shown in Table 1, in 2005 these businesses were estimated to have sales of about $35 billion annually and employ 209,000 people.

The businesses can be placed into individual analysis zones. The most important analysis zones in terms of dollar value of sales are shown in Table 2. The totals in Table 2 show that the vast majority of economic activity in the Delta is in a smaller number of islands. Zone 196 includes downtown Sacramento and adjacent areas from the American River south to and including the Pocket area. It should be noted that the primary Delta region has a limited number of businesses, and the majority of the costs would result from flooding of the outlying areas, particularly around Sacramento and Stockton.

Flooded businesses incur costs and impacts beyond the costs of repair and replacement of facilities and inventory. The FEMA (2005) methodology allows for displacement costs analogous to those for residential costs; a one-time cost when flooded, plus monthly costs based in part on costs for rented space. The FEMA methodology includes lost business income, but lost income should be counted only to the extent that sales cannot continue from the rented space. If a business is able to rent space, then some of the time of lost use does not result in lost sales. That is, either the business finds another space and keeps selling, or sales will cease. The economic cost analysis for lost sales assumes that sales stop for the duration of lost use and that businesses do not pay rental costs.

A goal of the analysis is to estimate impacts and costs from the California perspective. Some of the sales that are lost because of flooding will be picked up by other California businesses. From the perspective of California, the share of lost sales and profit that is replaced by sales from other California businesses should not be counted. IMPLAN provides regional purchase coefficients (RPCs) by economic sector that show the share of California demand that is met by California businesses. In the analysis, the RPCs are used to adjust the data on direct sales losses to account for the share of lost sales that will be made up by other California businesses. For sectors where all demand is met by California businesses there is no direct sales loss.

A further problem arises because of the need to estimate economic costs associated with lost sales. Lost income is not the same as economic cost. When income is lost some variable costs of materials, goods and sales are also avoided. Therefore, lost income will generally overstate economic costs. The lost profit associated with lost sales is the appropriate measure of economic cost.

Little information is readily available on profit rates by industry. Data at a national level for 2003 and 2004 show after-tax profit rates on sales of 5 to7 percent for manufacturing and 1 to 3 percent for wholesale and retail trade (USDC 2006). The profit rates on the trade sectors presumably apply to total sales, not the margin, but the business analysis counts only the margin (see discussion below). Therefore, profit rates as a share of the sales margin are larger than profit rates as a share of sales. It is assumed that the economic cost of lost sales is 5 percent of the lost sales amount, or in the case of retail, the sales margin. The 5 percent is applied to the amount of lost sales after applying the RPCs; that is, profit losses account for offsetting sales and profit increases by other California businesses.

The business sales data are linked to IMPLAN data to obtain estimates of total sales, value added and lost employment caused by flooding. Some business sectors are handled in a way that is unique to that sector.

- Agricultural businesses are covered by the agricultural land use analysis, so their sales must be excluded from this analysis to avoid double-counting.

Table 1
Study Area Business Profile
Billion $2005 of Output and Employment by Sector

Sector	NAICS [1].	Annual Billion $ Sales	Number of Employees
Agriculture	11299013	$0.21	1,132
Fishing	11421004	$0.01	25
Agricultural support	11531005	$0.08	827
Oil & gas	21111102	$0.01	2
Drilling	21311209	$0.03	135
Power generation	22112202	$0.11	39
Natural gas distribution	22121001	$0.00	4
Water, sewer	22131003	$0.02	65
Construction	23899096	$1.70	7,129
Manufacturing	33999940	$3.37	9,567
Wholesale & distribution	42512086	$9.14	12,021
Motor vehicles & parts	44132001	$0.93	2,034
Retail	45439017	$2.91	15,427
Transportation warehousing and storage	48899102	$0.62	4,918
Publishing, telecommunications, IS	51919020	$0.70	6,225
Financial, insurance, real estate, rental	53249013	$2.13	8,200
Services	56299806	$3.81	24,238
School & education	61171010	$0.09	9,611
Medical, day care, social assistance	62441006	$6.55	32,363
Entertainment	71399050	$0.27	5,629
Accommodations	72131006	$0.16	2,556
Restaurants etc	72241006	$0.53	11,173
Auto services, repair and maintenance, personal services	81299041	$0.47	5,240
Religious, civic	81399005	$0.13	6,350
Other	99999000	$0.03	39,202
TOTAL [2]		**$34.01**	**204,112**

1. NAICS number of the last business in that named group.
2. Note that this is the total for businesses protected by Delta levees. It is extremely unlikely that all analysis zones would flood in any particular scenario.

Source: InfoUSA data as of January 2006.

Table 2
Number of Businesses and Sales for Analysis Zones with Over $100 Million

URS_Name	Number of Businesses	Billion Dollars of Sales/year
Zone 196	10,741	$18.62
West Sacramento North	1,368	$5.82
Wright-Elmwood_Tract-Sargent Burnhart Tract	652	$1.18
Zone 159	157	$1.11
Zone 76	169	$0.97
Zone 126	290	$0.70
RD 17 Mossdale	162	$0.60
Victoria_Island	1	$0.45
SM-54	74	$0.44
Pierson District 1	47	$0.41
Zone 158	104	$0.29
Union_Island 1	13	$0.26
Van_Sickle_Island	13	$0.26
West Sacramento South 1	105	$0.22
Rough_and_Ready_Island	34	$0.20
SM-124	178	$0.19
Grand Island	43	$0.18
Sargent_Barnhart_Tract 2	120	$0.17
Shima_Tract	195	$0.17
Brannan-Andrus Island	148	$0.14
Browns_Island	0	$0.14
Zone 148	1	$0.14
Bouldin_Island	14	$0.13
Zone 157	167	$0.10
Zone 38	25	$0.10
Total	14,821	$33.0

Source: InfoUSA data as of January 2006.

- Many businesses that are listed as food manufacturers and wholesalers are actually vertically integrated farming operations. These businesses are handled by use of a factor to exclude the share of value of output that is farm value. That is, the direct loss of farm value is covered by the agricultural analysis, but the loss in value in forward processing, wholesaling and distribution is covered by the business sales analysis.
- A large number of businesses are marinas and related businesses. These businesses can be affected by changes in Delta recreation activity as well as flooding. Therefore, a link is provided to the recreation analysis whereby changes in Delta recreation activity can result in losses in recreation activity, and recreation businesses that are flooded will not incur any additional losses from lost recreation activity.

Many businesses in the Delta are retail businesses. The value of output of retail businesses should not include the wholesale value of the product that is sold. Rather, only the additional value represented by the difference in the wholesale and retail price is counted. This convention is also used by IMPLAN which is linked to this analysis. Therefore, a factor is included to discount the retail sales provided by the ESRI database to account for the wholesale value of the produce sold. This discount factor is 50 percent.

The analysis includes an option for counting the increased cost of renting space, or the rental income lost, by those businesses that are flooded. If a flooded business was renting, and it opts to continue operating, then it continues to pay rent somewhere else, but the property owner loses the rental income. If the flooded business owned its space, then it must pay rent somewhere else, and this is an additional cost. In either case, an economic cost is incurred.

For this measure again, little empirical information is available. The U.S. economic census provides sales and rental costs for some industries (USDC 2002). For manufacturing and construction, for example, costs of renting buildings were about 0.5 percent of sales. Rental costs alone surely understate the cost of space because the opportunity cost of owned space is not included. If this option is taken, it should be assumed that rental costs are 3 percent of the value of sales lost. The rental cost is applied to all businesses that are flooded before application of the RPCs. The rental cost option is not included in the results provided by this draft.

The FEMA method allows for a one-time cost to apply to any business that is flooded. Little useful guidance is provided as to the basis for this cost. It is assumed that any business flooded incurs a one-time displacement cost of $1,000.

An analysis is conducted for the 2030 condition using 2004 data and 2030 forecasts from Woods and Poole Economics (2006), which provides estimates for future employment and earnings by sector. These were used to estimate the value of output and employment, respectively, for 2030, by assuming that the increase in the real value of earnings is equivalent to the increase in real value of output.

Results by analysis zone are provided in Appendix A. A summary of impacts per day for all analysis zones under the MHHW event and the 100-year event flood condition is shown in Table 3.

Table 3
Summary of Business Sales and Cost Analysis 2005 and 2030
for All Analysis Zones
($2005 Million)

	MHHW Flood		100-year Flood	
	2005	**2030**	**2005**	**2030**
Number of businesses	883	883	15,930	15,930
Mil $2005 One-time cost if flooded	$0.88	$0.88	$15.93	$15.93
Losses per Day of Lost Use, Includes Backward Linkages				
Mil $ Value of Output	$1.05	$1.85	$24.40	$48.48
Person-years Employment[1.]	10	13	222	326
Mil $ Labor income	$0.35	$0.64	$8.41	$17.89
Mil $ Value Added[2.]	$0.58	$1.04	$13.08	$27.07
Mil $ Lost Profit	$0.05	$0.10	$1.22	$2.42

[1] One person year of employment is 365 persons unemployed per day
[2] Value added is labor income, proprietor's income, other property income and indirect business taxes
Note: This is the total for all analysis zones. It is extremely unlikely that all analysis zones would flood in any given scenario.

Public Services

The FEMA method allows for value of loss of public services to be estimated. Costs are based on the annual operating budget or revenues, functional downtime, and a continuity premium. For ordinary public services, the value of public services is estimated simply as the cost to provide them. A day of functional downtime is one day with no service or 2 days with 50% service, and so on.

For facilities that are critical for disaster response and immediate recovery, a "continuity premium" is applied to reflect the greater importance of such services during the flood. Continuity premiums are a multiplier on the normal daily value of services. For flooding, the continuity premium for police and fire stations allowed by FEMA is 10. For medical services, there is no continuity premium for floods.

The ESRI includes data for public services. Sales or cost of service are generally not provided, but number of employees is provided for most offices. Data on costs of public services and employment for some public agencies in the region were obtained from state and county sources (State of California 2007; Sacramento County 2007). These data resulted in estimates of budgeted costs per employee in Sacramento County are typically under $100,000. For some state agencies located in Analysis Zone 196, costs per employee range from $100,000 to over $1,000,000. The relatively large state costs are believed to reflect non-operating costs such as transfers to local governments and capital expenses which should not be included in operating costs.

It is assumed that the average cost of service per employee is $100,000, and the continuity premium of 10 times is applied for police and fire services. Given these assumptions, the costs of lost government services per day of lost use for all affected analysis zones is $13.72 million. Most of this cost; 88 percent, is associated with Zone

196. This zone includes 394 government offices, many of them being state government. Results by analysis zone are provided in Appendix A.

2.1.2 In-Delta Agricultural Losses

Scope and Magnitude of In-Delta Agriculture

DWR estimates there were 405,899 acres of harvested or grazed, irrigated crop acres in the Delta during the 1998–2004 period ((DWR 2006). The annual value of Delta agricultural production over this period averaged $680 million in 2005 dollars, of which 87% was associated with crop production and 13% with animal husbandry.

As shown in Table 4, over half of Delta agricultural production occurred in San Joaquin County. Sacramento County had the second largest share. Almost all of the remainder was distributed across Contra Costa, Solano, and Yolo counties. Alameda County accounted for a negligible amount of agricultural production in the Delta. Detailed estimates of crops and acreage by analysis zone, and estimated yield effects from salinity are shown in Appendix B.

Table 5 shows the production of field crops is the dominant agricultural land use in the Delta, accounting for 70% of irrigated acres, but only 22% of the dollar value of annual output. The other 30% of irrigated acreage is divided among truck crops (18%), orchards and vineyards (11%), and nursery and seed crops (1%). While accounting for only 30% of irrigated acres, 65% of the annual value of Delta agricultural production comes from these crops. Animal husbandry accounts for the remaining 13% of production.

Table 4
Delta Agricultural Production by County: 1998-2004

County	% Of Irrigated Acres	% Of Annual Production Value
Alameda	0	0
Contra Costa	7	8
Sacramento	20	19
San Joaquin	55	60
Solano	8	5
Yolo	10	8

Rounded to nearest whole percent.
Source: DWR 2006.

Table 5
Delta Agricultural Production by Crop Group: 1998-2004

Crop Group	% Of Irrigated Acres	% Of Annual Production Value
Field	70	22
Truck	18	32
Orchards & Vine	11	26
Nursery & Seed	1	7
Animal Husbandry	NA	13
Total	100	100

Rounded to nearest whole percent.
Source: DWR 2006.

Delta agricultural production is scattered across a large number of islands, diked land tracts, and upland areas. Approximately 80%-90% of the irrigated acreage in the Delta is within the 100-year flood plain (URS 2006). GIS mapping of the Delta developed by URS shows 96 analysis zones with 100 acres or more of irrigated agricultural land within the 100-year flood plain. These 100-year flood analysis zones range in size from 100 to 26,000 acres of farmland, with an average size of 4,100 acres.

Losses Due to Island Flooding

Three types of agricultural loss caused by island flooding were evaluated. These were (1) permanent loss of agricultural land caused by scour; (2) loss of crops due to land inundation; and (3) loss of investment due to death of permanent crops. [1]

a. Scour Impacts

Scour occurs at the levee breach site and is caused by the inrush of water through the breach. Scouring can result in large depressions rendering land permanently unsuitable to agricultural production. It is assumed there will be an average of 27.6 acres of scour per breach site. This assumption was provided to the economics team by URS, and assumes scour zone dimensions are 2,000-foot-long (perpendicular to levee) by 600-foot-wide (parallel to levee). The economics team prorated these acres between agricultural and non-agricultural land within each zone to estimate the total amount of agricultural acreage per breach that could be lost permanently from agricultural production as a result of scour. Total amount of acreage per analysis zone lost to scour depends on the number of breaches.

b. Agricultural Land Inundation

Agricultural land inundation[2] can result in economic loss by preventing planting, destroying crops in the ground, or preventing harvesting. The extent and magnitude of impact depends on the month or season in which flooding occurs, the duration of

[1] The Economics Team did not address losses to agricultural asset classes other than permanent crops and scoured acres, such as farm buildings, machinery, irrigation works, etc.. Losses to these asset classes were addressed by the Infrastructure Team.

[2] Farmers may also experience higher production costs for several seasons following a flood due to weed infestations and field irregularities, and may experience lower crop yields or shift to lower value crops until conditions improve. Data to support these secondary impacts was unavailable and they were therefore not addressed by the analysis.

inundation and the type of crops inundated. All else equal, losses from spring and summer floods will be greater than from fall and winter floods. Brief periods of inundation may result in only small damages if they occur after harvest and prior to spring planting. Longer periods of inundation occurring in the fall and winter may prevent spring planting altogether. Spring and summer flooding, regardless of the duration of inundation, will destroy most field and row crops in the ground.

c. Permanent Crop Impacts

Prolonged inundation may result in extensive damage or death of permanent orchard, vineyard and hay crops. The impact of inundation to crop yield and plant health is largely due to the very slow transport of oxygen through water. In addition anoxic conditions in the soil can lead to the release of toxic substances such as manganese. A review of the literature provided limited information on the affects of prolonged inundation on various crop types (see Appendix B for a summary) (Evans and Fausey 1999; Gilinski and Stepniewski 1983; Van't Woudt and Hagen 1957). Based on this review, the economics team adopted the assumption that inundation of 14 days or more would result in death of permanent crops.

d. Estimation of Agricultural Losses Due to Island Flooding

A spatial representation of agricultural production within the 100-year flood plain of the Delta was developed from URS, UC Davis, and DWR data sources (DWR 2006; URS 2006; UC Davis 2006). For the analysis zones defined by URS, the dataset includes total agricultural and non-agricultural acres and inundation depths within the 100-year and mean-highest-high flood plains; scour acres; and estimated crop mix.

The crop mix of each analysis zone was estimated using the UC Davis and DWR data sources. The UC Davis data provided crop mix by island while the DWR data provided crop mix by county. The UC Davis island-level data had cropping information for 75% of the acreage within the 100-year flood plain. The other 25% was unallocated. This unallocated acreage was assigned an average crop mix so that the resulting island-level crop mixes, when aggregated by county, matched the DWR county-level crop mixes for the Delta. Crops were aggregated into eight crop groups: (1) alfalfa; (2) field crops; (3) grain; (4) rice; (5) tomato; (6) truck; (7) orchard; and (8) vineyards.

Agricultural losses from flooding of an analysis zone are the sum of (1) scour impacts, (2) permanent crop loss, (3) field cleanup and rehabilitation, and (4) annual production losses.

- Scour Impacts. Scouring was assumed to render land unusable for farming or other uses. Scour impacts were defined as the amount of agricultural acreage lost to scour multiplied by the average agricultural land value for the analysis zone. Land values for the Delta were drawn from the California Chapter of the American Society of Farm Managers and Rural Appraisers' (CA Chapter's) 2005 Trends in Agricultural Land and Lease Values.

- Permanent Crop Loss. Inundation periods lasting 14 or more days were assumed to kill permanent crops. The analysis assumed permanent crops would be reestablished, either on the same acreage or in some other area. The loss to the grower was valued as the sum of the cost of stand establishment remaining undepreciated at the time of flooding and the loss of net income until the new stand is bearing.[3] The average stand was assumed to be halfway through its useful economic life. The analysis assumed average establishment costs of $7,200/acre for orchards, $9,000/acre for vineyards, and $505/acre for alfalfa (USACE 2002). Orchards were assumed to bear within four years of planting, vineyards within three years, and alfalfa within one year (Roberson 2007). [4]

- Field Cleanup and Rehabilitation. Floods of any duration or time of year may cause erosion and deposition of debris and sediment. Additionally, drainage and irrigation ditches may become clogged with silt and debris. An average cost of $235 per acre for clean-up and rehabilitation was assumed (USACE 2002).
- Annual Production Losses. Production losses were estimated for fall/winter and spring/summer flood events using the planting/crop loss decision rules shown in Table 6. The following assumptions underlie these rules. Three months is required following dewatering for cleanup and rehabilitation before fields can be prepared for planting.[5] Crops will not be planted after April. Inundation of more than 14 days will kill permanent crops and result in no harvest. Inundations occurring March through September will destroy row and field crops and either destroy orchard and vineyard crops or reduce their yields to the point that harvest is uneconomic.

  Loss of net farm income due to annual production losses is the difference between unrealized crop revenue and avoided variable production costs at the time of the flood event. These values were calculated using Delta crop revenue and cost estimates prepared by DWR and monthly distributions of crop production costs and revenues developed for the Sacramento and San Joaquin River Basins Comprehensive Study (DWR 2006; USACE 2002).

e. Farm Income/Output Loss Tables

Losses from flooding to farm income and output by analysis zones were formatted as lookup tables for subsequent use by the risk model. [6]

[3] For purposes of this analysis net income is defined as the difference between production revenue and avoidable production expense.
[4] Costs to reestablish asparagus were not included in the analysis because cost studies for asparagus establishment were unavailable. Reestablishment costs for pasture are aggregated with alfalfa.
[5] This assumption is based on the experience with Jones Tract.
[6] These tables were developed for incorporation into the risk model and are too large to reproduce as part of the Economics TM.

Table 6
Decision Rules for Determining Annual Production Losses from Levee Breach

Fall/Winter Levee Breach (Oct-Feb)				Mar-Sep Levee Breach
Dewater By Jan		Dewater After Jan		
Days To Dewater Island		Days To Dewater Island		
< 14	>= 14	< 14	>= 14	
Grain Crop Lost; Other Crops Go To Harvest.	Grain Crop Lost; Permanent Crops Killed (No Harvest); Other Crops Go To Harvest.	Grain Crop Lost; Other Annual Crops Not Planted; Permanent Crops Go To Harvest.	Grain Crop Lost; Other Annual Crops Not Planted; Permanent Crops Killed.	No Crops Harvested. Loss Estimate Depends On Month Of Flood.

<u>Losses Due to Water Quality Degradation</u>

Farm income losses may occur in Delta analysis zones unaffected by flooding when levee events increase salinity of Delta water used for crop irrigation. All crops do not respond to salinity in a similar manner; some crops produce acceptable yields at much greater soil salinity than others and there is an 8 to 10-fold range in salt tolerance of agricultural crops. The relative salt tolerance of most agricultural crops is known well enough to give general salt tolerance guidelines. Tolerances for many common field, vegetable, forage and tree crops are provided by the US Department of Agriculture's Salinity Lab. In general, all agricultural crops should yield at full potential when using water that has a salinity of less than 0.7 dS/m. The existing Delta water quality standards are designed to meet the 0.7 dS/m criteria. Therefore, the baseline assumption is that all crops are yielding at their full potential.

The soil salinity value at which there is no crop yield loss is referred to as the threshold ECe. Increasing ECe above the threshold will reduce yield. Relationships between ECe and yield are routinely used for irrigation water management planning. In the traditional planning context the known water quality, along with the amount of salt leaching is used to determine which crops can be successfully grown in a given area. In the context of a Delta levee event we assume a transient decrease in irrigation water quality. This assumption is based on the loss of some Delta islands due to flooding with the resulting water quality available for irrigation on the non-flooded islands being a mixture of seawater and fresh water. It is assumed that growers would use the resulting water quality as their sole source of water supply until higher quality water is available. Irrigation water quality was translated into soil water quality using the Food and Agriculture Organization (FAO) method. This method assumes long-term application of water of a given quality and that soil water quality develops over time. Transient changes in water quality following a levee event may not always satisfy this assumption. Consequently, our approach may overstate yield impacts for transient changes in Delta salinity.

The study used an established relationship between yield and crop sensitivity to salinity (Maas and Hoffman 1977, ASCE 103). The following equation is used to estimate yield based on the crop salinity threshold value and the yield loss per unit increase in salinity.

$$Y = 100 - b\ (EC_e - a)$$

where: Y = relative crop yield (percent)

EC_e = salinity of the soil saturation extract in ds/m

a = salinity threshold value

b = yield loss per unit increase in salinity

For example, given almonds with a water quality of 4 dS/m and a 15% leaching fraction the resulting yield is estimated to be 7% of full potential. Increasing the leaching fraction will improve the yield.

In addition to the overall salinity, crops are also susceptible to an increase in chloride concentration. Chloride is not adsorbed or held back by soils, therefore it moves readily with the soil-water, is taken up by the crop, moves in the transpiration stream, and accumulates in the leaves. Crop tolerances to chloride are not well documented. The values that are known were used to estimate the yield loss stemming from this constituent. The equation that is used is the same as the one used to estimate the yield decline due to an elevated salinity level.

Chloride concentrations are not an output of the DRMS water quality model. Therefore a linear dilution was assumed with seawater at an initial concentration of 545 meq/l chloride and 35 dS/m salinity. For example, if salinity is 10 dS/m then the chloride concentration is assumed to be 545/3.5 or 155 meq/l.

In most all cases the yield loss from chloride is greater than the yield loss for salinity. For example, alfalfa is expected to have 68% yield at a salinity of 4 dS/m. Assuming the cause of the increased salinity is ocean water, the chloride concentration would be about 62 meq/l, which will cause the alfalfa yield to decline to 44%.

a. Estimation of Agricultural Losses Due to Water Quality Degradation

Using the above formulation, the economics team estimated potential reductions in crop yield for each of the eight crop aggregates described previously. Yield of each crop aggregate was evaluated between 0.7 dS/m and 30 dS/m to generate a table of yield impacts for given salinity levels. A second table was calculated for chloride impacts. The economics team then calculated the loss of income per acre for each crop aggregate and each salinity level using Delta crop revenue and production data compiled by DWR (2006). Treating the chloride impact estimates as an upper-bound estimate of potential yield impact and the salinity impact estimates as a lower-bound estimate, the loss of income per acre can be formulated as a random variable following a triangular distribution for use in the risk analysis.

b. Use in Risk Model

The crop income loss tables can be combined with the analysis zone cropping data described previously to generate farm income/output loss estimates over the potential range of Delta water salinity. Average ambient water quality during the irrigation season for each analysis zone, which can be derived from output from the DRMS water quality model, can then be used to estimate the loss of agricultural income and output by analysis zone.

2.1.3 In-Delta Recreation Losses

This section describes the models and data used to estimate losses in consumer surplus, business income, value added, and employment from reductions in delta boating, fishing, and hunting recreation caused by Delta levee failure. Lost consumer surplus is used as the measure of economic loss due to reduced Delta recreation activity. Changes in recreation spending are used to measure statewide impacts to economic output, income, value added, and employment. Models for boating and fishing recreation within Delta recreation zones defined by the Delta Protection Commission (DPC) and for hunting, fishing, and wildlife viewing within Suisun Marsh are presented. A Delta Island Recreation Inventory is provided in Appendix C.

Delta Boating/Fishing Impacts

Damage to Delta levees may require parts of the Delta to be shut down to boating/fishing recreation for public safety or to facilitate repairs. Flooding may also destroy recreation infrastructure in the Delta, such as marinas, boat launches, and fishing access points. Loss of this infrastructure may also deter or prohibit Delta boating/fishing recreation. In the event of closures or destroyed infrastructure some affected recreation will shift to other parts of the Delta or outside the Delta. Small-scale events are expected to result in recreation mostly shifting to other parts of the Delta while large-scale events are expected to reduce the amount of shift within the Delta, but may induce a smaller amount of recreation to shift to outside the Delta.

Delta Recreation Data

Boating/fishing visitor-day data are from a California Department of Parks and Recreation 1997 Delta survey. Visitor-days are distributed across six Delta recreation zones and across the twelve months of the year. The six zones are shown on Figure 4. Further data are provided in Appendix C.

Zone A. This zone is the Sacramento River corridor, from the City of Sacramento south to Courtland. The inventory of recreation facilities in the Delta developed by the DPC indicates that the large Sacramento Marina, as well as three medium size marinas (50-200 berths), and five small marinas under 50 berths are located in this zone. Five launch ramps are located in this zone.

Zone B. This zone includes the Yolo Bypass, Cache Slough, and the Sacramento River Deep Water Ship Channel. Opportunities for recreational boating are very limited in this zone. There is only one marina.

Zone C. Zone C is the north Delta. It includes the Sacramento River from Courtland south to State Route 12 and all stretches of the Mokelumne and Consumnes Rivers which lie within the Delta. The City of Isleton and Snodgrass Slough are included. This zone includes seven launch sites, two public fishing access sites, two large marinas, seven medium marinas, and six small marinas.

Zone D. This is the west Delta, which includes the lower Sacramento and San Joaquin Rivers. Brannan Island State Recreation Area with its very large boat launch area is located here, along with two other public launch sites. Eleven large marinas are located here, as well as 15 medium marinas, and 26 small marinas.

Zone E. This zone is the east Delta. It is bordered on the north by State Route 12, on the east by Interstate 5, and on the south by State Route 4. It includes portions of the City of Stockton, eleven boat launch ramps, six large, eight medium, and three small marinas.

Zone F. This zone is the south Delta. State Route 4 forms its northern boundary, Interstate 5 its eastern border, and Interstate 205 its southern boundary. Discovery Bay and Clifton Court Forebay are located here, as well as three public and one private launch ramps.

Figure 4 Delta Recreation Zones

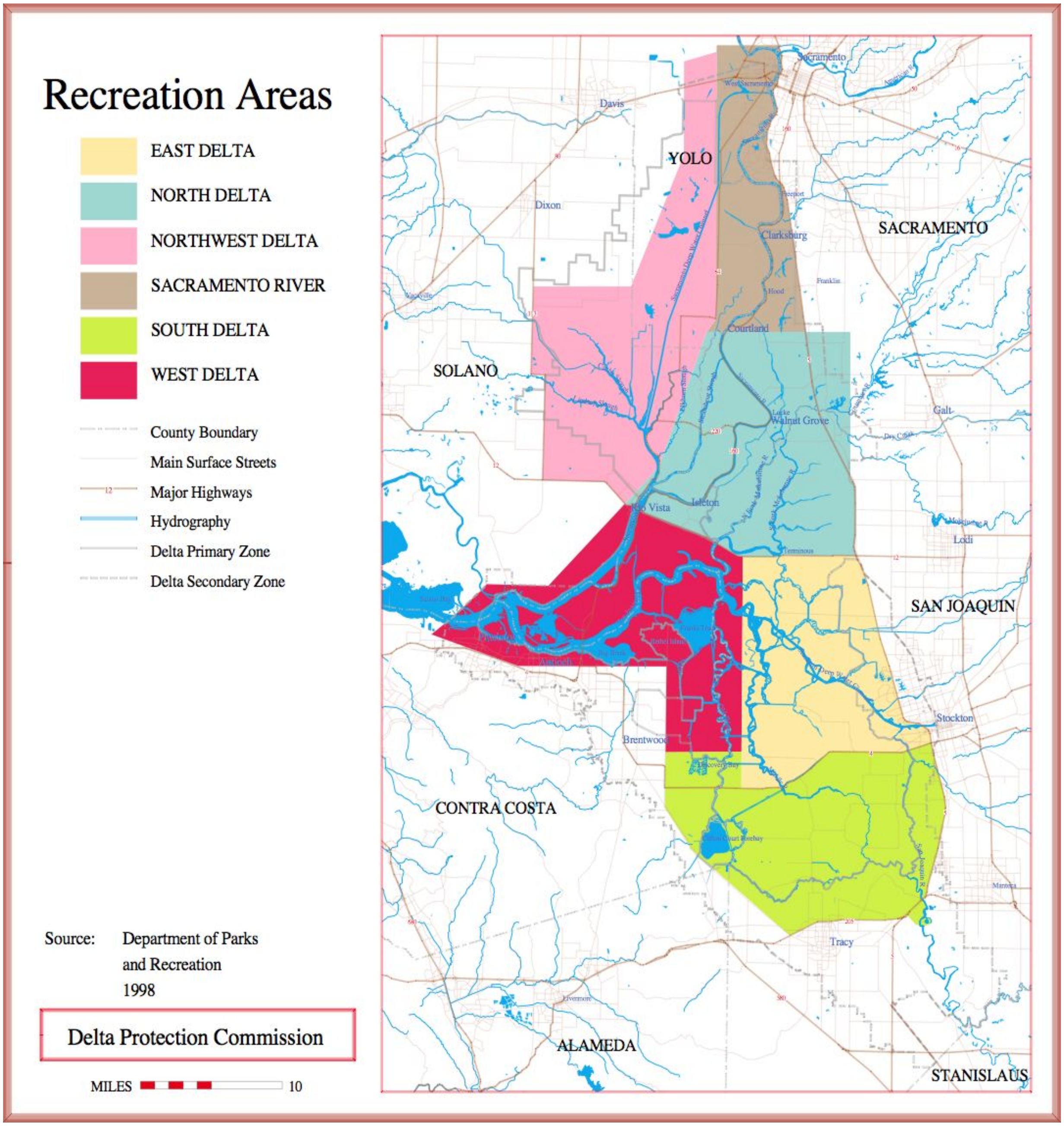

Table 7 shows the distribution of boating visitor-days by recreation zone and Table 8 shows the monthly/seasonal distribution of boating visitor-days. Figure 5 shows the distribution of visitor days and boat berths by recreation zone. The source data for these tables are provided in Appendix C.

Table 7
Geographic Distribution of Boating Visitor-Days

Recreation Zone	% of Boating Activity	No. Responses
A	9.5%	392
B	3.4%	139
C	19.7%	816
D	35.4%	1,465
E	22.9%	948
F	9.0%	374
Total	100.0%	4,134

Delta islands were matched with recreation zones using two maps. The first was the "Draft 100-Year Floodplain Based on FEMA Flood Zone Data" map prepared by URS. The second was the recreation zone map shown on Figure 4. Islands were matched to zones by visual inspection. Islands crossing zone boundaries were assigned to the zone that contained most of the island area. Appendix C lists the islands and recreation zone assignments. It also provides an inventory of marinas, boat berths, and dedicated fishing access sites.[7] These were developed by matching locations of marinas and fishing access sites shown on DPC maps to islands listed on the URS map. This was necessary because the DPC maps do not show island names and provide only a general representation of Delta land areas. The matching was done by visual inspection. Average number of berths for each size class of marinas was calculated from the DPC recreation inventory and then multiplied by the number of marinas of each class on an island to estimate the number of marina berths by island. Figure 5 shows the distribution of visitor days and boat berths by recreation zone.

a Visitor-Day Valuation

The consumer surplus of a Delta recreation visitor-day was taken from Mitchell and Wade (1991). The output, income, and value added generated by a Delta boating recreation visitor-day were taken from Goldman et al. (1998). All dollar values from these sources are converted to 2005 constant dollars prior to use in the models. Standard errors for the consumer surplus and economic impact estimates were not reported in the originating studies. Standard errors were approximated for these variables using results from other studies.

Loomis and Kaval (2003) and U.S. Fish and Wildlife Service (USFWS 2003a) report consumer surplus estimates for wildlife-based recreation in California and the Pacific

[7] This does not include the many informal fishing access points throughout the Delta, and thus provides a very incomplete distribution of land-based fishing recreation. Because of this incompleteness, it is not used in the modeling.

Coast region as shown in Table 9. These estimates are similar in magnitude to Wade et al.'s consumer surplus estimate for Delta recreation. The estimates have similar coefficients of variation, averaging around 0.20. We used this average value for the coefficient of variation to approximate the standard error for average consumer surplus of Delta recreation.

Table 8
Monthly Distribution of Boating Visitor-Days

Month	% of Boating Activity	Season	% of Boating Activity
Jan	2.9%	Winter	8.9%
Feb	3.5%	Spring	23.3%
Mar	5.6%	Summer	43.1%
Apr	7.6%	Fall	24.7%
May	10.1%		
Jun	13.3%		
Jul	15.4%		
Aug	14.4%		
Sep	12.0%		
Oct	7.9%		
Nov	4.8%		
Dec	2.5%		
Total	100.0%		100.0%

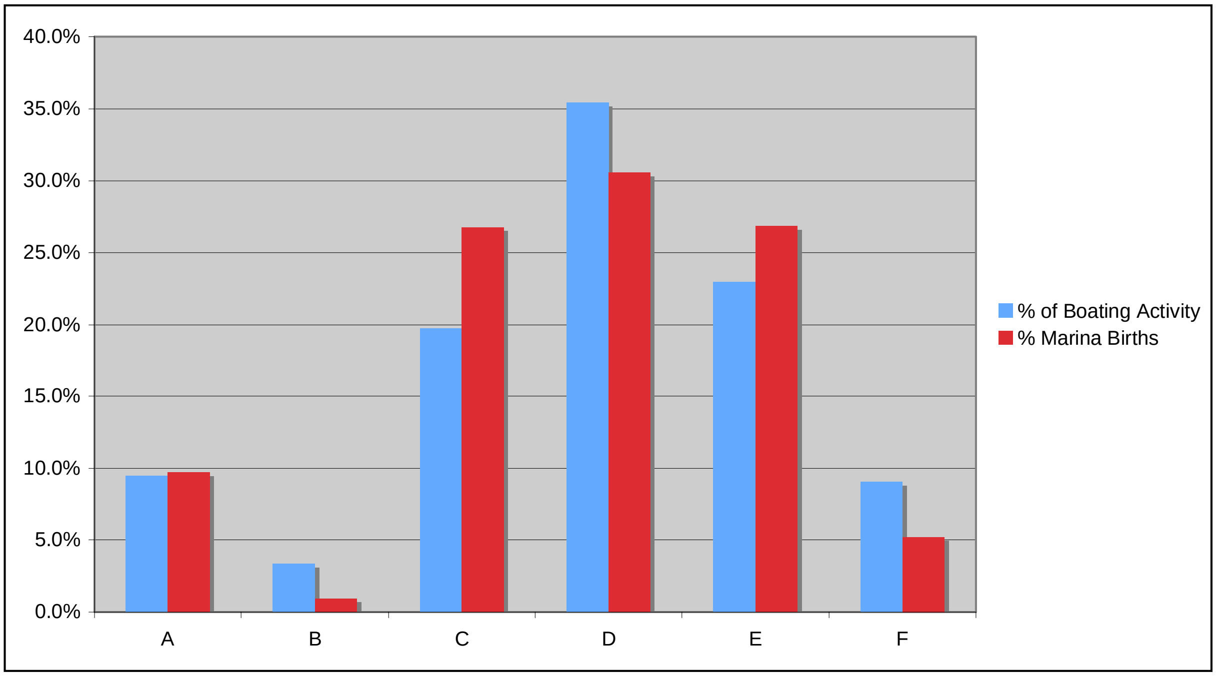

Figure 5 Distribution of Visitor-Days and Boat Berths by Zone

Table 9
Mean Recreation Consumer Surplus and Standard Errors

Activity	Mean Consumer Surplus	Standard Error	Coefficient of Variation	Source
Wildlife Viewing	43	9	0.209	USACE 2002
Wildlife Viewing	75	17	0.227	CA Chapter 2005
Trout Fishing	64	10	0.156	USACE 2002
Fishing	46	9	0.197	CA Chapter 2005
Motorboating	28	6	0.214	CA Chapter 2005

Likewise we use the coefficient of variation for average trip expenditures for fishing and wildlife viewing in California reported in USFWS (2003b) to approximate the standard error of Delta recreation trip expenditures reported in Goldman et al. (1998).

b. Delta Boating/Fishing Impact Model

A flooded island model was developed to calculate lost visitor-days, consumer surplus, and economic impacts as a function of the list of islands flooded by a levee event and the duration each island is out of service. Details of the model used are found in Appendix C.

The key limitation of the flooded island model is its use of lost boat berths as a proxy for lost visitor-days. This assumption is based on the correlation between berth and visitor-day location, but is not empirically derived.

The model uses boating visitor-days as a lower-bound estimate for total fishing and boating visitor days and therefore may undercount total boating/fishing visitor-days. This is necessary because the fishing and boating visitor-day counts from the recreation survey are not additive. Many respondents to the recreation survey reported both boating and fishing activities for the same day. Adding the two counts would double count a substantial number of visitor days. Thus, both models assume implicitly that all fishing in the Delta occurs from boats.

The model does not account for changes in recreation due to changes in the quality of the experience. It is only capable of estimating changes in recreation due to changes in recreation access.

Suisun Marsh Hunting/Wildlife Viewing Impacts

Estimated recreation user-days by activity for Suisun Marsh are based on unpublished July 2005 to June 2006 visitor data for the Grizzly Island Wildlife Complex operated by Department of Fish and Game. These data were obtained during a telephone communication with the manager of the Grizzly Island Wildlife Complex, Pat Grahm, on November 16, 2006. Mr. Grahm used attendance records for the complex to estimate user-days by activity. He also provided the approximate percentage of total Suisun Marsh recreation this represented. The data are presented in Table 10.

Table 10
Suisun Marsh Use Estimates (2005-06)

Activity	Grizzly Complex	% of Marsh Total	Total Suisun Marsh
Wildlife Viewing, Dog Training, etc.	12,500	100%	12,500
Fishing	30,000	65%	46,154
Waterfowl hunting	6,000	*	67,620
Pheasant hunting	1,300	75%	1,733
Elk hunting	40	100%	40
Pig, Rabbit hunting	125	100%	125

* Private clubs in Suisun Marsh = 158 clubs x 10 hunters/day x 3 days/wk x 13 wks = 61620; Estimation method independently proposed by Pat Grahm and Steve Chappell of the Suisun Resource Conservation District.
Source: Telephone communication with Pat Grahm, Grizzly Island Wildlife Complex

The monthly distribution of user-days by activity was developed using the activity access calendar for Grizzly Island Wildlife Complex (Table 11). We assume user-days are uniformly distributed across months in which an activity is permitted to occur. Mean economic values per user-day and their standard errors for different activities occurring at Suisun Marsh selected for the analysis are summarized in Table 12. Average trip expenditures per user-day by activity were derived from user-day and expenditure data collected by USFWS (2003 a) in *2001 National Survey Fishing, Hunting, and Wildlife Associated Recreation, California*. Mean expenditures and associated standard errors are shown in Table 13.

Table 11
Suisun Marsh Recreation Months Activity Permitted to Occur

Recreation Activity	Occurs
Hiking, Viewing	Feb-July
Fishing	Feb-July
Water Fowl Hunting	Oct-Jan
Pheasant Hunting	Nov-Dec
Elk Hunting	Aug-Sep

Table 12
Consumer Surplus Values – Suisun Marsh
($/User-Day, 2005Dollars)

Activity	Mean	Standard Error	Source
Wildlife Viewing, Dog Training, etc.	42.90	8.80	USFWS 2003a
Fishing	45.84	8.97	Loomis and Kaval 2003
Waterfowl Hunting	47.01	7.99	Loomis and Kaval 2003
Pheasant Hunting	47.01	7.99	Loomis and Kaval 2003
Elk, other Hunting	2.40	16.50	USFWS 2003a

Table 13
Trip Expenditures Per User-Day By Activity

Mean Expenditure Per User-Day ($/User-Day; 2005$)				
Activity	Food & Lodging	Transportation	Other Trip Costs	Total
Fishing	17.73	9.24	17.96	44.92
Hunting	19.99	13.51	17.58	51.08
Wildlife Viewing	24.55	13.88	2.27	40.70
Activity	Standard Errors			
Fishing	2.10	1.09	2.13	5.34
Hunting	5.29	3.56	4.64	13.57
Wildlife Viewing	3.33	1.88	0.30	5.53

Source: California Data Exchange Center user-days by activity from Tables 3 and 25, expenditure by activity from Tables 19, 20, and 33, and standard errors calculated using formulas in Appendix D.

Flooding within Suisun Marsh affects recreation primarily by disrupting or closing roads used by marsh visitors to get to its recreation sites. We assume that if a levee event floods Suisun Marsh access to the marsh for recreation will be closed for the duration of the inundation plus one month, due primarily to road closures.[8]

Some affected wildlife viewing and fishing recreation may shift to other locations following a closure. We do not have data to estimate the extent of the possible substitution. We assume the percent of affected wildlife viewing and fishing recreation user-days that shift to unaffected locations follows a symmetric triangular distribution with a mean of 25 percent and a range between 0% and 50%. We assume affected hunting recreation will not shift to other locations due to lack of substitution

[8] According to DFG personnel, this is, in fact, what occurred in January 2005 when the marsh flooded. The primary impact was road damage, which caused Grizzly Island Wildlife Complex to cancel the remainder of the 2005 waterfowl hunting season. Personnel communication, Grizzly Island Wildlife Complex staff, November 15, 2006.

possibilities.[9] The formulas for consumer surplus loss estimates are provided in Appendix C.

2.1.4 Disruption to Water Supplies

Water Supplies to Agriculture

Some levee events will disrupt CVP and SWP Delta pumping and may reduce south of Delta (SOD) CVP and SWP deliveries relative to the baseline condition. In cases where SOD CVP and SWP deliveries are reduced, growers and districts will adjust operations to minimize income losses. In regions with developed groundwater pumping capacity, growers and districts will substitute groundwater subject to physical and economic limits. In some cases, groundwater substitution will eliminate the shortage. In other cases, the shortage will remain. In these cases, available water supply will be rationed. Rationing could take many forms and will be locally determined. However, it is reasonable to assume that within relatively confined geographic regions supplies will be directed, either by administrative fiat or through economic incentives, first to permanent crops, second to high value row crops, and third to forage and pasture.

At the level of the individual farm, the farmer must decide at the time the project water delivery reduction is announced which crops already in the ground to continue producing and which crops not yet in the ground to move forward with. The farmer's choices will be guided by expected returns to production. For example, the farmer could choose to abandon crops in the ground in order to make water available for crops not yet planted if this would minimize the loss of farm income.

This section describes the economic team's modeling approach for estimating likely agricultural production responses to temporary disruptions of project water deliveries and resulting changes in farm output and income.

Analysis Regions

Four SOD agricultural analysis regions were considered: (1) the San Felipe Unit of the CVP; (2) Central Coast regions receiving SWP water; (3) South Coast regions receiving SWP water; and (4) San Joaquin Valley regions receiving SWP and CVP water.

a. San Felipe Unit

Agricultural water supplies from the San Felipe Unit of the CVP are conjunctively used with groundwater. Agricultural lands within the San Felipe Unit can shift entirely to groundwater when project deliveries are disrupted. Groundwater resources in the area are sufficient to sustain current levels of farm production through disruptions lasting up to four years. Groundwater tables are high and pumping costs are cost competitive with CVP water. Groundwater quality is impaired in some parts of the service area, which could limit the planting of some row crops, such as lettuce, on overlying lands. These higher-value crops could shift to areas of unimpaired groundwater quality. Overall, impacts to agricultural production due to disruption of project water deliveries are expected to be small to negligible and therefore are not modeled.

[9] Waterfowl hunting sites in California are limited and many are rationed through a reservation system.

b. Central Coast Regions

Groundwater is the primary water supply for Central Coast agriculture. Limited amounts of SWP water supply is conjunctively used with regional groundwater resources. Groundwater resources in the area are sufficient to sustain current levels of farm production through disruptions lasting up to four years. Overall, impacts to agricultural production due to disruption of project water deliveries are expected to be small to negligible and therefore are not modeled.

c. South Coast Regions

Retail agricultural water deliveries by Metropolitan Water District of Southern California's (MWDSC's) member agencies are currently about 300 thousand acre-feet per year (TAF/year). Additionally, MWDSC delivers approximately 105 TAF/year under its Interruptible Agricultural Water Program. Combined deliveries total about 405 TAF/year. Agricultural production in the region is expected to decline steadily over the next two to three decades. By 2030, MWDSC estimates agricultural deliveries of 250 TAF/year, about 62% of the current level.

Unlike for the San Joaquin Valley, existing agricultural production datasets are not available. To date the economics team has been unable to compile a sufficiently complete set of data to incorporate the South Coast agriculture into the modeling framework. The team is continuing with data collection.

In addition, many of the water districts in Southern California have extensive groundwater basins, and rely on SWP deliveries to overcome historic overdrafts of these aquifers. The recharge programs have been quite successful, so it is assumed that a limited (i.e., not permanent) reduction in SWP supplies could be largely offset by increasing the drawdown of these groundwater basins.

d. San Joaquin Valley

San Joaquin Valley agricultural water demands are met through a combination of local surface water, groundwater, and project water deliveries. Within regions of the valley receiving CVP or SWP water, project deliveries supply approximately 40% of agricultural demands, groundwater about 40%, and local surface supply about 20%. Groundwater is treated as a swing supply, which can be increased or decreased depending on the state of project and local surface water deliveries.

CVP water deliveries to San Joaquin Valley agriculture averaged about 3.5 million acre feet (AF)/year over the period 1993 through 2005. Delta exports accounted for approximately 60% of this delivery. Delivery from the Friant Unit accounted for the other 40%. SWP water deliveries to San Joaquin Valley agriculture averaged about 1.1 million AF/year over the same period.

As a share of total agricultural supply, CVP and SWP deliveries vary through the valley from as little as 5% in some areas to as much as 90% in others. Access to local surface and groundwater also varies substantially throughout the valley. To account for this variation, the San Joaquin Valley was divided into eleven subregions for analysis. These subregions are the same as the subregions used by the Central Valley Production Model (CVPM) agricultural production model and DWR's C2VSIM groundwater model. Figure 6 shows all CVPM subregions within the Central Valley. The subregions included in the agricultural impact analysis are: 10 and 13-21. These are the subregions receiving CVP and SWP supply. Subregion 10 was further divided between CVP exchange contractors and CVP agricultural contractors so that the analysis could treat exchange contractor water supplies and production responses separately. Table 14 provides a brief description of the agricultural water users in each region modeled, and Table 15 provides summary water supply and production information for the regions.

Table 14
CVPM Regions and Descriptions

CVPM Region	Irrigation Areas Included
R10	Delta Mendota Canal, CVP Users: Panoche Pacheco, Del Puerto, Hospital, sunflower, West Stanislaus, Mustang, Orestimba Patterson, Foothill, San Luis WD, Broadview, Eagle Field, Mercy Springs, Pool Exchange Contractors, Schedule 2 water, more.
R13	Merced ID CVP Users: Chowchilla, Madera, Gravelly Ford
R14	Westlands WD
R15	Tulare Lake Bed, CVP Users: Fresno Slough, James, Tranquility, Traction Ranch, Laguna Real, Dist. 1606
R16	Eastern Fresno C. CVP Users: Friant-Kern Canal, Fresno 10, Garfield, International
R17	Friant-Kern Canal, Hills Valley, Tri-Valley Orange Cove
R18	Friant-Kern Canal, County of Fresno, Lower Tule River ID, Pixley ID, Portion of Rag Gulch, Ducor, County of Tulare, most of Delano Earlimart, Exeter, Ivanhoe, Lewis Cr., Lindmore, Lindsay-Strathmore, Porterville, Sausalito, Stone Corral, Tea Pot Dome, Terra Bella, Tulare
R19	Kern Co. SWP Service Area
R20	Friant-Kern Canal, Shafter Wasco, S. San Joaquin
R21	Cross-Valley Canal, Friant-Kern Canal, Arvin Edison

Note:
For this analysis, Region 10 was separated into Exchange Contractors and others to appropriately reflect the greater reliability of water supplies to Exchange Contractors.

ID = Irrigation District

WD = Water District

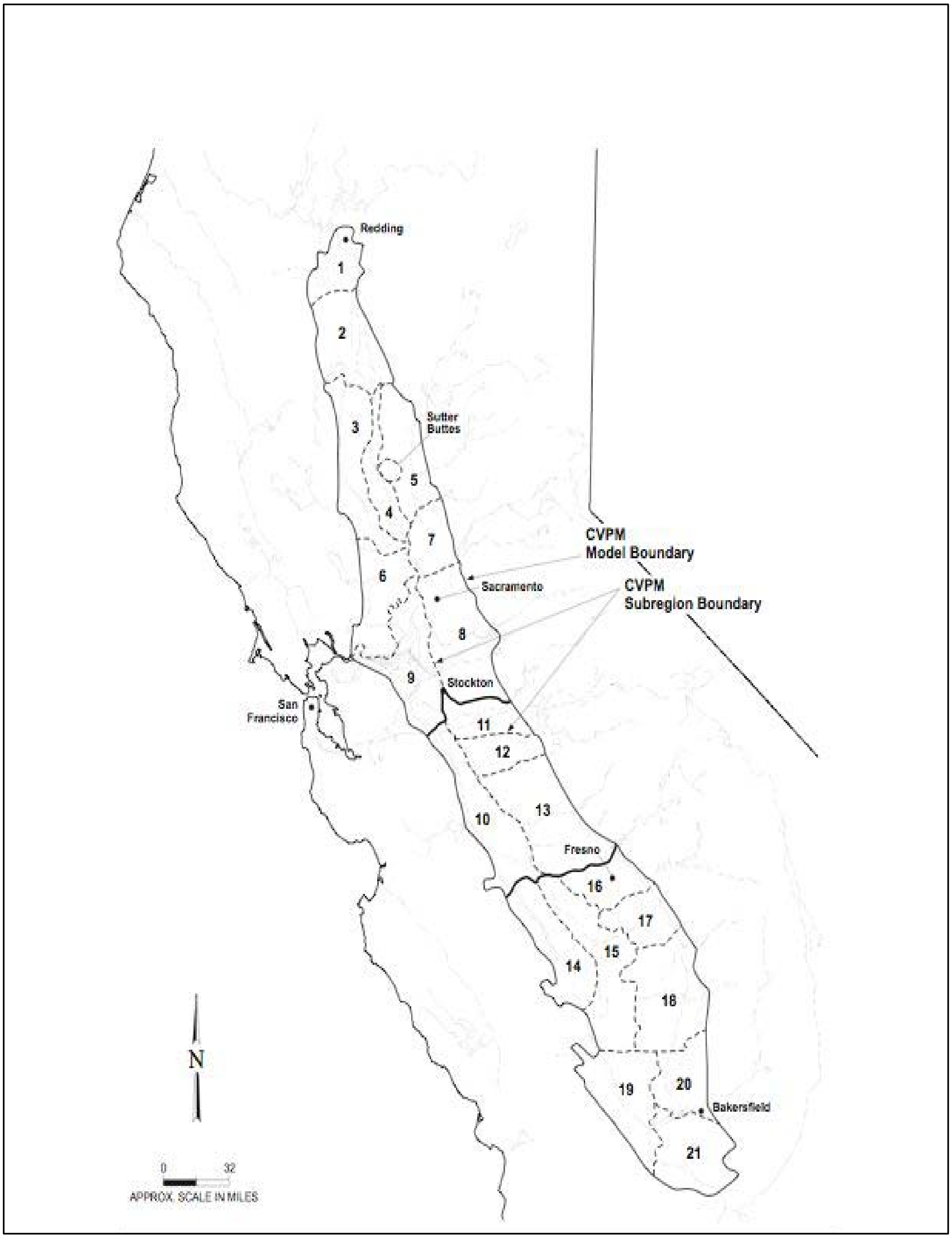

Figure 6 Location of CVPM Subregions Modeled

Table 15 Regional Water Supplies[1] (TAF/Year), Permanent Crops And Gross Crop Revenue[2]

Modeling Region	Water Supplies					
	CVP (Delta + Friant)	SWP	Local Surface & Groundwater	Total Supplies	% Of Acreage In Permanent Crops	Gross Crop Revenue ($Million)
R10A	360	5	64	429	17%	366
R10B	657	-	-	657	5%	277
R13	317	-	454	771	46%	1,082
R14	986	-	211	1,197	9%	931
R15	84	265	334	683	17%	803
R16	62	-	272	334	71%	352
R17	33	-	295	328	86%	646
R18	508	-	335	843	38%	1,215
R19	-	737	27	764	25%	487
R20	539	58	20	617	70%	545
R21	107	357	156	619	24%	670
TOTAL	3,653	1,421	2,168	7,241	33%	7,376

R10A = Non Exchange Contractors, R10B= Exchange Contractors
[1] Water supplies are for year 2000, a recent year with average levels of Delta export supplies.
[2] Crop revenues are in millions of 2002 dollars.
Source: Central Valley Production Model (CVPM)

Primary Determinants of Agricultural Income Losses

The primary determinants of SOD agricultural income losses will be (1) the month or season in which the project delivery disruption begins, (2) the magnitude and duration of the disruption, and (4) availability of local surface and groundwater supplies to replace project deliveries.

a. Month/Season of Disruption

The month or season in which disruption begins will determine crops already harvested, crops planted but not yet harvested, and crops yet to be planted. It will also determine the amount of storage in San Luis and Millerton Reservoirs and level of agricultural water demand over the coming months. Disruptions occurring in late spring and summer months will result in larger impacts than those occurring in the fall and winter months.

b. Magnitude/Duration of Disruption

The magnitude and duration of change in CVP and SWP Delta pumping coupled with stored water in San Luis and Millerton Reservoirs will determine the level of CVP and SWP deliveries to SOD agricultural areas. Long disruptions (say 6 months or more) may result in severe water shortages among some CVP contractors, may raise human health and safety concerns within some M&I service areas and could result in no CVP water delivery to some agricultural areas. It is possible that long Delta outages will result in reoperation of Millerton Reservoir to partially meet exchange contractor and refuge demands. SOD SWP deliveries will depend on current SWP shortage allocation rules. These rules will determine the amount of SWP water stored in San Luis going to Kern

County Water Agency, Central Coast SWP contractors, and Southern California SWP contractors.

c. Groundwater Substitution

SOD agriculture will replace disrupted project water with groundwater to the extent economic and physical conditions permit. The potential for groundwater substitution varies by region and depends on a number of factors, including: (1) existing pumping capacity, (2) potential to add additional pumping capacity, (3) groundwater costs, (4) ability to move groundwater through existing canal systems, and (5) legal ability and economic incentive to transfer groundwater. URS hydrologists compiled information for the economics team on the first three factors. The results of their analysis as well as the core groundwater assumptions used for the agricultural impact analysis are presented in Appendix D. The analysis assumes groundwater resources are uniformly distributed throughout each modeled region. This assumption was necessary because of a lack of data on the distribution of groundwater resources within each region.

d. Local Surface Water

Local surface water supplies are specified for each region. These are long-term annual averages by year-type. For this analysis, we assume that agricultural users are not able to outbid urban areas for additional surface water supplies available through the transfer market.

SOD Farm Income Loss Model

The SOD Farm Income Loss Model estimates the change in SOD farm income relative to a baseline condition given a temporary reduction in CVP and SWP project water deliveries. The model assumes farmers have available in the short-run two production responses to reduced project water deliveries: (1) they can substitute groundwater for project water; and (2) they can reduce crop production to balance water demands with available water supply. The model selects the response combination that maximizes farm income subject to water balance and groundwater pumping capacity constraints. Farm income loss is then calculated as the difference in farm income between the baseline condition and the shortage condition. A mathematical representation of the optimization model is presented in Appendix D.

Implementation of the model required the following types of data:

- *Baseline Acreage and Crop Mix.* The CVPM datasets were used to implement the model for the San Joaquin Valley region. Baseline acreage and crop mixes were developed for wet, normal, dry, and critical year types. Individual crops were combined into the 14 crop aggregates listed in Table 16. Baseline acreage and crop mix was developed for each subregion in the model.

Table 16
Crop Aggregate Mapping

Crop Aggregate	Crops Included
Orchard	All orchard and vineyard acreage
Grain	All grain crops except corn and rice
Corn	Corn grain and silage, not sweet corn
Rice	Rice
Cotton	Cotton
Sugar Beets	Sugar Beets
Safflower	Field crops other than sugar beets
Dry Bean	Dry Beans
Alfalfa	Alfalfa, other hay crops, and pasture
Processing Tomatoes	Processing Tomatoes
Fresh Tomatoes	Fresh Tomatoes
Onion & Garlic	Onion and garlic
Potato	Potato, all varieties
Truck	All other melon and vegetable crops

- *Annual Crop Revenue and Cost*. The CVPM datasets were used to calculate baseline per acre variable cost and revenue for each subregion in the model. Costs and revenues for each crop aggregate were calculated as an acreage-weighted average of costs and revenues for the crops comprising the aggregate.
- *Monthly Distribution of Annual Crop Revenue and Cost.* Crop cost and return studies published by the U.C. Cooperative Extension were used to develop monthly distributions of variable production cost and revenue for each crop aggregate.
- *Monthly Applied Water.* The CVPM datasets were used to calculate annual per acre applied water for each crop aggregate. Applied water for each crop aggregate was calculated as an acreage-weighted average of the crops comprising the aggregate. Crop cost and return studies published by U.C. Cooperative Extension were used to develop the monthly distribution of applied water for each crop aggregate.
- *Baseline Project Water.* The CVPM datasets provided baseline project water deliveries and costs for each subregion. Baseline project deliveries were developed for wet, normal, dry, and critical year types.
- *Local Surface Water.* The CVPM datasets provided the quantity and cost of local surface water for each subregion in the model. Local surface water estimates were developed for wet, normal, dry, and critical year types.
- *Baseline Groundwater Pumping.* The model calculates baseline groundwater pumping endogenously to balance the water budget for each subregion. The CVPM datasets were used to calculate the average cost per acre-foot of groundwater pumping for each subregion. The amount of baseline groundwater pumping varies by year type.

- *Additional Groundwater Pumping Using Existing Capacity.* The model determines the amount of additional groundwater pumping endogenously subject to pumping capacity and water balance constraints for each subregion. The monthly pumping capacity constraints and cost of additional groundwater pumping are based on the groundwater information developed by URS presented in Appendix D.
- *Additional Groundwater Pumping Using New Capacity.* The model determines the amount of additional groundwater pumping from new wells endogenously subject to well installation, pumping capacity and water balance constraints for each subregion. The well installation and pumping capacity constraints and cost of additional groundwater pumping from new wells are based on the groundwater information developed by URS presented in Appendix D.

e. Model Objective Function

The model maximizes net farm income subject to a constraint set. Net farm income is defined as the difference between unrealized crop revenue and remaining variable production cost. Remaining variable production cost depends on the month the project water delivery reduction begins as well as the extent of additional groundwater pumping. Likewise, unrealized crop revenue depends on the month the project water delivery reduction begins. The model optimizes the objective function by selecting the amount of baseline acreage to fallow for each crop aggregate. If no acreage is fallowed the model reproduces the baseline output level.

f. Model Constraint Set

The model constraint set includes crop fallowing constraints, groundwater pumping and development constraints, and a monthly water balance constraint. The crop fallowing constraints prevent fallowing from exceeding baseline acreage and ensure permanent orchard crops remain in production. There are three groundwater constraints. The first places a limit on the amount of additional groundwater pumping from existing well capacity. The second limits the rate at which new well capacity can be added within a subregion. The third places a limit on the amount of additional groundwater pumping from added wells. The water balance constraint ensures that monthly applied water does not exceed available water supply, after adjusting for conveyance losses and tailwater recovery.

g. Stored Surface Water

The model assumes that water districts can carryover unused surface water for delivery in subsequent months. Unused surface water in a given month is the difference between local and project water deliveries plus baseline groundwater pumping and applied water for that month.

h. Additional Groundwater Pumping

Additional groundwater pumping occurs in a given month if applied water exceeds local and project water deliveries, stored surface water, and baseline groundwater pumping. Additional groundwater pumping can come either from existing capacity or new wells. The amounts available from each source are subject to constraints, as described previously. The cost of additional groundwater pumping from existing capacity is a function of the baseline variable pumping cost and the calculated change in pumping lift. The cost of additional groundwater pumping from new capacity is this cost plus an adder for the annualized cost of well development. Cost functions were developed using the groundwater information developed by URS presented in Appendix D.

Farm Income/Output Loss Tables
The SOD Farm Income Loss Model was run over the range of possible starting shortage months, shortage durations, and project water shortage magnitudes to map the model solution spaces for each subregion. Shortage durations were expressed as the number of months that project deliveries to a subregion are below baseline as a result of the levee event. Project water shortage magnitudes were defined in 5% increments, running from 0% through 100%. Solution spaces were developed for wet, normal, dry, and critical year types. Results were formatted as lookup tables for subsequent use in the risk analysis.

Probability Distribution Function of Farm Income/Output Losses
There is significant uncertainty in the subregional estimates of existing groundwater capacity. In order to reflect this uncertainty in the farm income/output loss estimates, existing groundwater capacity was modeled as a random variable following a triangular distribution. The upper and lower bounds and mid point of pumping capacity for each subregion were based on the groundwater pumping capacity estimates developed by URS. The SOD Farm Income Loss Model was then run at each of the three capacity levels to map the associated solutions spaces. The risk model can use the resulting lookup tables to represent farm income/output losses as a random variable following a triangular distribution.

2.1.5 Water Supplies to Urban Users

The methodology used to estimate the effects of a disruption of Delta export water supplies to urban users consisted of the following three-step process:

1. Determine urban water agencies likely to be affected by levee failure in the Delta.
2. Collecting data necessary to estimate the level of shortage in affected agencies.
3. Estimating the cost of shortage for each agency.

Agencies Susceptible to Being Affected
The first step is to determine the agencies susceptible to being affected. These are primarily the urban water contractors of the SWP and of the CVP and Contra Costa Water District (CCWD). The North Bay SWP contractors were assumed to experience only temporary interruptions because the strong flow of the Sacramento River past intakes for the North Bay Aqueduct would likely freshen water at that point in the Delta very quickly. Because of this no economic consequences are expected for these contractors.

In addition to the SWP and CVP water users, East Bay Municipal Utility District (EBMUD) could be affected because the conveyance for its major source of water (the Mokelumne Aqueduct) crosses the Delta and could be damaged or disrupted by Delta levee failure.

Once the initial identification of these agencies was made, the 2005 Urban Water Management Plans (UWMPs) were collected and reviewed to determine the size of the urban population at risk, and the alternative sources of water. Table 17 lists the agencies identified and the 2005 and 2030 population estimates.

This review identified some agencies that used SWP water to overcome groundwater overdraft. These agencies had extensive groundwater resources, but had been using them at an unsustainable rate. However, these agencies could likely survive for some years without SWP imports by “mining” their groundwater, so long as they could expect that the SWP deliveries could recommence at some time in the future. Of course, to make this determination, it was necessary to estimate a maximum time that the disruption would be likely to last. The assumption was made that four years would be the maximum disruption analyzed. The basis for this assumption was that if it appeared unlikely that water supplies would resume in that time-frame, agencies would have the time and the need to implement plans to develop alternative supplies.

A second finding from this preliminary analysis was that the San Francisco Public Utilities Commission (SFPUC) was interconnected to a number of water agencies in the Bay Area that were at risk from Delta disruption. The SFPUC provides wholesale water supplies to a number of Bay Area retail agencies, many of them also supplied by Santa Clara Valley Water District (SCVWD). The SFPUC also has emergency interconnections with EBMUD. In an extended outage, the SFPUC would likely provide some limited assistance to Bay Area agencies if they were experiencing steep cutbacks. In the 1976-77 drought such local agency support was forthcoming when an emergency pipeline was constructed across the Richmond Bridge to provide water to Marin County. Since the 1991 drought, smaller emergency interconnections between specific Bay Area agencies have been constructed. However under the Business as Usual analysis, no additional support from the SFPUC was assumed to be forthcoming.

Estimating the Levels of Shortage by Agency

The analysis presented in Table 17 shows that the size of the urban areas served range from the City of Dos Palos at 4,800 to MWDSC, serving more than 18 million people. Because of the large number of agencies to be investigated, the complexity of the analysis and the limited time available, it was decided to restrict the analysis to the larger agencies and develop the estimate of economic consequences for the remaining agencies by extrapolation. Table E-1 in Appendix E shows the agencies that were modeled, and also identifies those that were assumed able to mine groundwater for the modeled extent of the duration. This table shows that the agencies modeled accounted for 96 percent of the total population likely to be affected in 2005, and 97 percent of that population in 2030.

Because of their size and economic importance, as well as their dependence on Delta water supplies, the agencies chosen for modeling were in the Bay Area counties and Southern California. However, not all agencies are equally dependent on water supplies from the Delta. Table 18 shows the counties that were included in the model, the population and value added within each county, and the percentage of the county’s water supplies that are obtained from the Delta.

Table 17
Population With Urban Water Supplies Potentially Affected by Delta Levee Failures

		Population	
Supplier	**Agency**	**2005**	**2030**
SWP/CVP/SFPUC	Santa Clara Valley Water District[1]	1,750,000	2,267,100
CVP	Contra Costa Water District	507,800	649,300
CVP	City of Tracy	70,800	160,100
CVP	City of Avenal	16,200	23,500
CVP	City of Coalinga	17,100	24,800
CVP	City of Dos Palos	4,800	7,000
CVP	City of Huron	7,000	10,200
	Subtotal CVP[2]	2,373,700	3,142,000
SWP	Alameda County Water District	324,000	405,900
SWP	Alameda Zone 7	196,000	264,000
SWP	Kern County Water Agency	326,000	458,000
SWP	Antelope Valley- East Kern	313,500	650,400
SWP	Palmdale Water District	109,800	214,300
SWP	San Gabriel Valley Municipal WD	217,000	239,800
SWP	Castaic Lake Water Agency	235,000	401,700
SWP	Desert Water Agency	68,000	100,000
SWP	Coachella Valley WD	314,300	490,600
SWP	Crestline-Lake Arrowhead Water Agency	34,500	46,100
SWP	Mojave Water Agency	358,800	700,000
SWP	San Bernardino Valley Municipal WD	661,700	1,097,700
SWP	MWDSC	18,233,800	22,053,200
SWP	Central Coast Water Authority	409,000	618,200
SWP	Casitas Municipal WD	66,200	78,800
	Subtotal SWP[2]	23,617,600	30,085,800
	Total Export Projects[3]	**24,241,300**	**30,960,700**
EBMUD	EBMUD	1,338,000	1,017,000
	Total Potentially Disrupted[3]	25,579,300	31,977,700
SFPUC	Hayward (SF)	146,000	162,800
SFPUC	San Francisco WD	798,000	871,000
SFPUC	San Mateo	698,600	806,600
	Potentially affected through interconnections[4]	1,642,600	1,840,400
	Total Potentially Affected[3]	**27,221,900**	**33,818,100**

Notes
1. SFPUC does not serve SCVWD but supplies water to SCVWD retail customers
2. Includes SCVWD
3. SCVWD included only once
4. Not including those in SCVWD service territory
Source: Urban Water Management Plans as cited in Appendix E
SFPUC populations from BAWSCA 2006.
For smaller CVP towns, from San Joaquin Council of Governments 2006
http://www.sjcog.org/sections/departments/planning/research/projections

Table 18
The Influence of Urban Water Supplies from the Delta

County	County Population Estimates 2005	2004 County Value Added $ Million	Delta % Of Co. Water Supply
Alameda	1,515,000	75,489	24%
Contra Costa	996,823	45,518	47%
Los Angeles	10,205,568	428,942	39%
Orange	3,078,200	166,529	36%
Riverside	1,753,932	47,022	20%
San Bernardino	1,855,900	50,871	21%
San Diego	2,966,000	138,678	44%
Santa Clara	1,750,000	121,157	50%
Ventura	658,346	31,049	47%
Other	654,043		
Total	**25,433,812**		
Mokelumne Aqueduct			
Alameda	849,000		51%
Contra Costa	489,000		43%
Subtotal	1,338,000		
Total Delta Influence	**25,433,812**	**1,105,255**	
State	**36,810,000**	**1,556,255**	

From this table, it is clear that the counties responsible for much of the economic activity in the state obtain at least part of their urban water supply from the Delta. Some counties are at particular risk: Contra Costa County, for example, is served in the main part by two agencies, CCWD, and EBMUD. Both of these agencies obtain the vast majority (over 90 percent) of their water supplies either from the Delta, or from the Mokelumne Aqueduct that crosses the Delta. Contra Costa County gets 47 percent of its supplies from the Delta, and a further 43 percent from the aqueduct for a total of 90 percent of supplies at risk. Similarly, Alameda County obtains 24 percent of its water from the Delta, and 51 percent from the Mokelumne Aqueduct, for a total of 75 percent at risk. Agencies in both counties have limited local storage, so a Delta failure with a ruptured aqueduct would put the economies of those counties at considerable risk. EBMUD has taken preparations to minimize the time that the Aqueduct would be out of service, but CCWD relies on the Delta itself, and so has fewer options to minimize the effect of Delta failure. Other counties are less dependent on Delta water supplies, and more generally have larger amounts of local storage.

To analyze the effects of a failure of Delta water supplies, a subset of agencies was mailed a survey and asked to provide monthly demand and water supply information for 2005 and 2030 under varying water supply conditions. A copy of the survey used is provided in Appendix E. Responding to this survey appeared more difficult than expected; agencies were not used to developing data on a monthly basis, and there were legal and other process issues that prevented some agencies from responding. Where necessary, monthly assumptions were developed by the analysts based on the annual data from the UWMPs. There is no doubt that the lack of input from some agencies increases the uncertainty in the analysis.

Using the monthly agency data, either supplied by agencies or by the analysts, a simplified mass balance model was developed for each agency. This model includes local supply options. An estimate of local supplies available by month was developed that recognizes constraints on these local supplies, such as maximum monthly withdrawal rates, inflows to local storage under differing water year types, and initial water in local storage under wet, normal, dry and critically dry conditions. The two agencies modeled with the largest amount of locally controlled water storage were MWDSC and SCVWD. For MWDSC, water stored in facilities under local control was obtained by historic hydrologic years. Similar data were not available for SCVWD, so the ratio of water in storage to total capacity in MWDSC's Diamond Valley Reservoir was used to estimate the amount of water stored by SCVWD by hydrologic year.

The Water Analysis Module (WAM) provides monthly water deliveries from the SWP and CVP to these agencies under baseline conditions that vary by hydrologic year, and then estimates what deliveries would be under a Delta closure scenario with the same hydrology. The water estimated to be in storage with the local agencies was then determined either by matching the year type (wet, normal, dry, and critically dry) or by historical hydrologic year. Then, the cumulative local supplies available by month were compared to cumulative local demands for the baseline analysis and outages of differing lengths. For the disruption scenarios it was assumed that agencies could not withdraw groundwater from agencies such as Semitropic, where delivery of the water is dependent on deliveries to Semitropic through the Delta. The exception to this is deliveries to MWDSC, but these were assumed restricted to the amount that could be delivered by operating MWDSC's share of the pumping capacity at the groundwater storage. The WAM model also dispatches water from storage south of the Delta without regard to the reservoir in which it is stored. Thus the analysis may overstate the ability to deliver water from Del Valle reservoir. This assumption simplified the analysis, and was also justified because it was assumed that under emergency conditions SCVWD could obtain some of its SWP water through its CVP connection with San Luis Reservoir, thus leaving additional water in Del Valle for delivery to Zone 7 and Alameda County Water District.

A different cumulative shortage value was estimated for each month of the disruption, and the largest cumulative monthly shortage estimated was adopted. This was chosen over the average shortage, because it is expected that water supplies from the projects would return to more-nearly normal levels in the last months of a disruption. However, this water would not be available throughout the period, and so the use of an average shortage over the entire period of disruption would understate the impact. In previous droughts where water use has been constrained, demands remained lowered for some time after the water shortage was no longer in effect. It was therefore felt to be more appropriate to model a level of shortage that could mean that some water available in the last months of a shortage would not necessarily be used, than a model that assumed that the water that would only be available from the end of the disruption period was available throughout the disruption.

It should be noted that this approach is less conservative than that likely to be taken by water managers under an actual Delta failure condition. Water agencies are likely to call for conservation efforts before they are actually needed. While the failure of one island in the Delta is unlikely to prompt calls for conservation, at some unknown level above that agencies would likely call for voluntary conservation of, say, ten percent of usage as a prudent response to the situation, regardless of whether they expected there to be sufficient water supplies in local storage. In addition, where an extended outage is expected agencies might call for more conservation than would be needed, to insure both against shortfalls in conservation efforts and the risk of failure to meet repair timelines. Both of these managerial decisions were impossible to model, and so were ignored. However, they would likely result in increased costs to the California economy.

Further modeling was developed to reflect the situation after Delta operations were restored. It is possible that agencies might be able to withstand the effect of Delta restrictions with minimal costs, but at the price of drawing down local storage. This would leave them with increased vulnerability to drought in the years immediately following a Delta disruption. This increased vulnerability must be included as part of the cost of levee failure. However, this part of the model developed average shortages for each calendar year after the Delta is reopened. The use of averages for this part of the model was chosen to reflect the greater operating flexibility that pertains with a fully operational Delta.

After conferring with the infrastructure repair group, it became clear that the Mokelumne aqueduct was only likely to fail as a result of levee failure if the aqueduct were in the scour zone of a levee break. The Aqueduct's three pipelines are close together, so it was assumed that if one pipeline failed they would all fail. As a result, the EBMUD situation was modeled with either a failure or non-failure mode. No modeling was developed for the post disruption situation for EBMUD, because it was assumed that the storage situation would not change as a result of the aqueduct break. Rather, water would be stored in upstream reservoirs to the extent that it was not available for use by consumers. Any outage of the aqueduct would be limited to a maximum of six months for multiple ruptures, so the only possible effect on storage would be that if a wet winter occurred while the aqueduct was broken, there might be some small reduction in the total amount that could be stored. If the water supply were plentiful enough to require additional spill at EBMUD's upstream reservoirs, there would be little likelihood of a water supply shortage once the aqueduct resumed operations. This contrasts with the situation for the project exporters, where water in upstream reservoirs could be depleted to flush the Delta, and to maintain minimum flows over a much more extended outage period.

Estimating the Cost of Shortage by Agency Analyzed

The shortage cost by agency analyzed was estimated using the shortage loss function developed for use in DWR's Least Cost Planning Simulation Model (LCPSIM) model, as updated for use in the Common Assumptions process to evaluate reservoir storage. This is a polynomial equation of the form:

$$SC_{a,c} = 774.75 + 25254.35 * AS_{a,c} - 16396.5 * AS_{a,c}^{2} - 3527.79 * AS_{a,c}^{3}$$

(CH2M Hill 2006)

where

$SC_{a,c}$ is the shortage cost per acre foot not delivered in agency a to customer group c.

$AS_{a,c}$ is the adjusted shortage in percent experienced by customer group c in agency a.

The shortages here are varied by customer group type, and are adjusted to reflect the following issues:

a. Agencies will try to protect different end-users by different amounts. The order of protection is as follows (from most protected to least protected): industrial, commercial and institutional, residential, landscapes. The adjustment factors used for the equation are those developed for LCPSIM and the Common Assumptions program.

b. Agencies that have already invested in conservation will have experienced "demand hardening" that will make the shortage more costly. The adjustment for the demand hardening effect is also that used for LCPSIM and the common adjustments program.

The data needed to develop these cost estimates were obtained from the agencies UWMPs. The shortage costs estimated by agency and customer group were multiplied by the appropriate number of acre-feet and summed to get the total shortage cost for agencies analyzed. The calculations used to develop these estimates are presented in Appendix E.

However, it was found that this functional form became less useful at shortages above 45 percent of demand. Below that level, shortages can be concentrated disproportionately on residential consumers and landscaping consumption, while protecting uses by commercial industrial customers. This reduces the overall economic cost of any shortage. However, once the system-wide shortages are above 45 percent, all water use to landscape has been eliminated, and shortages to households are above 50 percent. At that point agencies will need to start placing stronger constraints on commercial and industrial uses, with a resulting rapid increase in economic costs. The LCPSIM estimation formula was not developed to extend to this level of shortage, and was in fact based on data related to shortages of thirty percent, not more than 45 percent.

To develop a robust approach that would hold for an unknown range of shortages, the performance of the LCPSIM equation was examined at levels of 100 percent shortage, to make an estimate of how reliably the equation was performing at that level. While it is unlikely that many agencies would reach that level of shortage, it was expected that CCWD, which relies entirely on Delta water, could reach levels of shortage that were well outside the levels at which the LCPSIM equation was fitted.

An example estimate was made for Santa Clara Valley, which showed that the maximum economic cost under the LCPSIM formulation for 100 percent shortage for the county as a whole was estimated at $18 billion per year. This was based on zero availability of water from any source, and no ability for the water agency to minimize costs by maximizing deliveries. It should be stressed that this level of shortage is not expected in the county. This extreme scenario was merely posited as a cross check to verify the performance of the LCPSIM economic cost estimate at ranges of shortage far outside the boundaries of the shortages for which it was estimated.

This $18 billion dollar estimate was disappointingly low. The value added for the county was estimated as $121 billion per year (IMPLAN). Thus the LCPSIM estimate would suggest that delivering no water in the county would merely reduce the county's economic activity by less than 15 percent. The 15 percent estimate is an upper bound on the estimated effect on commercial and industrial economic activity, because it does not allow for any of the costs this should be reduced by the considerable economic costs of zero water deliveries to residential customers. Thus we concluded that the LCPSIM function was not providing appropriate estimates of costs outside of the boundary of values for which it was estimated.

We decided that it the value most likely to approximate the economic cost of zero water deliveries was the estimate of value added within the region. This will overstate the cost of disruption to industry and commerce, because some of the value added in Santa Clara County in normal water supply situations could be replaced by increased activity in other counties of the state. For example, if a hamburger store in Alameda County was not able to sell hamburgers because of the lack of water, some people who would otherwise have bought hamburgers in Alameda County would instead by hamburgers in Santa Clara County, so all economic activity would not be lost. However, this level of shortage would occur when a number of other counties in the state would also be experiencing water shortages, so the amount of economic activity that could transfer to those other counties would be limited. In addition, some economic activities are tied to specific locations and equipment (for example, oil refineries) and lack of suitable equipment or capacity constraints would also limit the amount of economic activity that could transfer to other counties rather than being lost to the state.

Based on this reasoning, we assumed that the economic losses for 100 percent shortage would approximate the value added for the area shorted. Because this would overestimate the loss to commercial and industrial activities, we did not add anything to reflect residential losses, and did not adjust the total to reflect the populations served that were not in the major areas analyzed.

Thus the shortage cost estimates developed were structured in three distinct phases, as follows:

Shortage Level	Source of Costs	Comments
0-45 percent	LCPSIM Shortage cost function, increased by percentage of consumers in the smaller agencies not analyzed.	Fitted for shortages in the range of 0-30 percent
45 – 85 percent	Constant percentage increases from LCPSIM value at 45 percent to 85 percent of value added.	Shows most rapid increases in costs as shortages approach 85 percent. No allowance for residential costs or consumers not included.
85-100 percent	Linear interpolation to 100 percent losses at 100 percent shortage.	Little activity left as the shortage approaches 100 percent.

It should be stressed that these estimates are highly uncertain, because such levels of shortage have not been experienced. In addition, the structure of the county economies change over time, so the economic costs experienced at one time could be expected to change over time. Part of the economic cost data relied on for the LCPSIM shortage cost estimates is two decades old, but more recent analyses are not available.

Where counties are served by more than one agency, it was assumed that the economic costs would be in proportion to the population served. For example, in Contra Costa County the CCWD serves approximately 50 percent of the population of the county, while the majority of the remaining population is served by EBMUD. It was assumed that if CCWD experienced 100 percent shortage, while EBMUD experienced no shortage, the economic costs would be equal to half of the value added in Contra Costa County. It may be that, for example, EBMUD serves a lower proportion of non-residential uses in the county, in which case this assumption could underestimate the costs of not serving water to CCWD's service territory, but we did not have information that allowed us to develop an estimate that was any more targeted than we have described above.

The economic costs and impacts estimated in this manner for various levels of shortage are shown in Appendix E. It should be noted that the majority of counties and agencies are unlikely to experience shortages greater than 50 percent, because the share of water obtained from the Delta is seldom greater than 50 percent.

2.1.6 Infrastructure of Statewide Importance

Mokelumne Aqueduct

The Mokelumne Aqueduct consists of three pipelines that carry water from the Calaveras watershed across the Delta to EBMUD. As discussed previously, these pipelines are considered vulnerable to scour, and not to flooding. Because the pipelines are located in the same right of way, it is assumed that all will be lost if a breach occurs in close proximity to the lines. The loss of these pipelines reduces the ability of EBMUD to provide reliable water service to its consumers. In addition, if the aqueduct is in place it can be used to provide supplementary supplies to CCWD in the event that it was unable to obtain sufficient supplies from the Delta. The economic consequences resulting from failure of this asset is considered as part of the analysis of water supplies to urban users. In general, it is expected that under most scenarios the aqueduct would be repaired within one month of rupture, and take up to six months to repair multiple ruptures. EBMUD expects to have sufficient water in local storage to maintain deliveries for a one month outage, and to experience a shortage of less than 25 percent for a six-month disruption.

Deep Water Shipping Channels

The Ports of Sacramento and Stockton could be closed by a flood event. Additional costs are based on the cost of moving freight by rail instead of by ship. Data on recent tonnage is provided by the California Association of Port Agencies. Recent volume was 0.7 and 2.9 million metric tons in Sacramento and Stockton, respectively (California Association of Port Authorities 2005). The additional transport cost by rail per metric ton is $0.026 (Association of American Railroads 2005) and it is assumed that freight would move by rail for 40 additional miles. The cost of outage per day is estimated to be $2,085 for Sacramento and $10,157 for Stockton.

Electric Transmission

The analysis of consequences arising from failure of electric transmission assets in the Delta is divided into two sections; the first addresses the major 500kV lines, and the second the remainder of lower voltage transmission lines.

Major 500 kV Transmission Lines

Three major electric transmission lines cross the Delta: the California Oregon Transmission Project operated by the Western Area Power Administration, the Pacific Gas and Electric (PG&E) 500 kV Table Mountain-Tesla line, and the PG&E Vaca-Dixon-Tesla line. These lines work mainly to interconnect California loads and generation with loads and generation in the Pacific Northwest. The three lines through the Delta are operated as a coordinated grouping, with maximum imports or exports limited to provide some joint redundancy to help ensure reliability.

The combined load on these three lines is typically around 4000 mW, although under some circumstances it can be as high as 4800 mW (Mirzadeh 2006). This is approximately ten percent of statewide summer loads, which is less than the required planning reserve margin of 15 percent. However, there may be other outages that occur at the same time as this disruption, so under some circumstances the loss of all three lines could cause operating problems.

The western utilities have had regulations aimed at ensuring the reliability of these transmission lines for some time. Increased confidence in the robustness of the system led to some relaxation of these regulations. In the summer of 1996 high loads in California and a wet hydro year in the Pacific Northwest had led to a high level of imports over these power lines. The heat caused sagging transmission lines, and the transmission system came into contact with vegetation, causing system instability. At the same time, a number of other events occurred that resulted in cascading problems through the western states, causing widespread power outages. Since then, the Western Electric Coordinating Council (WECC) has developed a “safety net” operating procedure with the goal to ensure stable operation of the transmission system under all failure modes (Patterson 2007).[10] However, the 1996 outage and other, more recent transmission outages in the Midwest and Northeast regions suggest that even advanced security arrangements cannot avoid all problems.

To develop an understanding of the possible outcomes to electric transmission from Delta levee failure, the operation of these three major lines was considered under three scenarios:

1. Levees fail as the result of winter storms, in which case there would likely be some warning that a levee breach was likely. Under this scenario, if multiple line failures were to occur, they would be likely to occur sequentially, rather than instantaneously. Because the flooding would occur in winter, electric loads would

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[10] The WECC is a forum for companies and agencies to work together to promote electric system reliability. The WECC region extends from the Canadian provinces of Alberta and British Columbia down to the northern portion of Baja California, Mexico, and includes all or portions of the intervening 14 western states.

be lower than the higher summer loads, so generation could be more readily adjusted to meet the loads on the system. Under this scenario the electric system operators would be most likely able to operate the system so as to minimize any problems. The major resulting impact would be that electric generators in California would not be able to sell power to the Pacific Northwest, so these generators would lose income.

2. A levee fails as the result of a single non-weather occurrence as occurred in Jones Tract in 2004. If the situation were to occur in summer, some limited controlled load shedding might be
3. Levees fail as the result of earthquake, in which case there could be multiple outages, and the disruption could occur in summer or winter. However, the earthquake would likely result in failure to serve at a local level, which would also reduce electric load. For example, an earthquake on the Hayward fault might damage substations along the fault-line, bring down local distribution poles and lines, and power-using equipment would likely be adversely affected. Such an earthquake could cause instability in the system, because demands and supplies would become unmatched with or without the loss of the transmission lines. These sudden changes in the system could possibly result in widespread outages, but these outages would most likely be the result of the earthquake rather than any levee breaches.

Thus under most circumstances the result of flooding would be the reduced ability to operate the west coast power system in the most efficient way possible. In summer, this would lead to increased reliance on more expensive power plants located in California or the Southwest, while in winter, it will reduce the ability of California generators to sell power to meet the winter loads in the Pacific Northwest. However, if the best precautions of the WECC members are insufficient, there could be a more widespread loss of load.

To develop the most likely forecast of economic losses associated with a loss of transmission lines in the Delta, we have relied on an analysis performed by the PG&E transmission planning group. They analyzed the effect of the loss of their two 500 kV lines during different seasons. The analysis showed little impact in non-summer months, but in summer months the analysis showed increased costs resulting from the use of less-efficient generation within California. The results of their analysis are presented in Table 19, and was used to develop a per month estimate for the loss of one to three of the 500 kV lines over summer months.

For an estimate of a worst-case situation, we have relied on an estimate of the 1996 experience produced by the Western Systems Coordinating Council, an earlier version of the WECC. These are described in Appendix F of this report. The results of these studies are that the most likely economic consequences are those reported in the following table. There is an extremely low level of probability that in an earthquake scenario the worst-case outcome could be as much as $500 million per incident in addition to these losses, as discussed in the infrastructure appendix. However, this should be considered very low probability: less than 1 percent of the time that such a failure occurs.

Table 19
Cost of Two Month Outage, Two 500-KV Lines

	Locational Marginal Cost ($/MWh)	Load Payment (Million$)	Locational Marginal Cost ($/MWh)	Load Payment (Million$)	Cost of Outage (Million$)
	Two-Line Failure		Baseline (No Failure)		
July					
PG&E Valley	$45.48	364	$44.34	348	15
PG&E Bay	$47.34	214	$44.72	198	16
Southern California	$44.47	541	$44.36	539	1
San Diego	$44.49	89	$44.41	88	0
August					
PG&E Valley	$45.56	329	$45.33	326	3
PG&E Bay	$47.03	221	$46.17	215	6
Southern California	$45.50	569	$45.46	568	1
San Diego	$45.53	96	$45.49	96	0
				Total Cost	42

Source: Chen (2007)

<u>Transmission Lines Below 500 kV</u>

The major consequence of failure of these transmission lines is estimated to be the loss of ability to serve loads in the Delta. Service to other locations could most likely be maintained through the use of other existing transmission lines. In the event of levee failure, some existing loads in the Delta may be reduced – for example, if households are evacuated, then the loads from those households would be removed; if agricultural areas flooded, irrigation and drainage pumps in those areas would be turned off or damaged. Thus the consequence of failure of these lines could range from zero (if all loads that could not be served were no longer requiring service) to loss of the entire load in the Delta, which PG&E estimates at 1900 mW (Palomares 2007). It is assumed that these losses will be small, so they have not been quantified.

<u>Future Conditions</u>

The discussion of the economic consequences of transmission failure outlined above is based on current conditions. The losses associated with failure of the 500 kV system will likely decrease over time because few if any new reservoirs are being constructed in the Pacific Northwest. Indeed, it is suggested that some of these dams will be removed when they come before FERC for relicensing. Whether the reservoirs are removed or remain in place, as the economy of the Northwest grows, there will likely be less surplus hydroelectric generation for purchase in the Northwest. The current transmission expansion plans (through 2030) do not include any additional capacity along this transmission corridor (Consortium for Electric Reliability Technology Solutions 2003). There will still likely be exchanges that take advantage of the ability to use generation investments more intensively, but the current regional differentials in generation cost will likely diminish over time.

Highways

Interstate 5, several important state highways and important county and local roads pass through some of the analysis zones. Flooded highways would require travelers to use alternate routes until floodwaters are removed and roads cleared of debris and repaired. Types of costs associated with this include increased travel time and expense for persons who must use another route, increased congestion on alternative routes, lost trips, and business costs associated with delays. Table 20 shows highways in the study area that could be closed in the 100-year event, and the analysis zones they cross. The analysis of costs of lost use of roads focuses on Interstate 5, several important state highways (4, 12, 160 and 220) and county road J11. It should be noted that not all highways will be closed as a result of levee failure. The highways closed will depend on the analysis zones flooded in any scenario.

California Department of Transportation (Caltrans) provides data on average annually daily traffic (AADT) for state and federal highways (Caltrans 2006). The data are provided as traffic flows in both directions on each side of specified points on the highway. For the major highways of interest, AADT on Highway 4 between Oakley and county route J4 is currently about 20,000, and volume falls to about 10,000 on Highway 4 from the junction of J4 to Stockton. AADT on Highway 12 through the Delta is currently just under 20,000. Highway 160 through the Delta has an AADT of about 15,000. AADT on J11 is much less, about 3,000. AADT on Interstate 5 from Stockton to Sacramento is about 60,000.

Two methods were used to estimate costs of lost use of highways. First, a quadratic programming model of the Delta highway system was developed and applied. Second, an existing software package and database known as the Risks from Earthquake Damage to Roadway System (REDARS) was applied.

The quadratic programming network model of the regional road system represents traffic flows as equations. A model schematic is provided as Figure 7. The model uses AADT data from Caltrans to establish initial conditions. For the 2030 model, 2004 AADT data are increased to 2030 levels using rates of growth from recent years.

Table 20
Potentially Flooded Highways and Analysis Zones Crossed

Highway	Analysis Zones
12	Brannan Andrus, Bouldin, Terminous Tract 2, Terminous Tract 1
I-5	Zone 196, 75, 76, 78, 171, Glanville Tract, New Hope, Canal, Brackt, Terminous, Shin Kee, Rio Blanco, Bishop, Zone 185, Shima, Sargent Barnhart 2, Wright-Elmwood Sargent Barnhart, Zone 157, 158, 159, RD 17
I-5/205	Stewart, Pescadero
4	Roberts, Victoria, Byron
160	Sherman

Table 20
Potentially Flooded Highways and Analysis Zones Crossed

Highway	Analysis Zones
220	Ryer, Grand
J11	Tyler Island, Staten Island, New Hope Tract
Note: Highways closed will depend on zones flooded in each scenario analyzed.	

FEMA provides a cost of $32.23 per hour of additional travel time caused by a road outage. For each highway, an average speed is assumed for the baseline condition. With speed, AADT and the cost per hour, baseline costs of travel can be derived. Then, a flood scenario removes one or more of the links from the model corresponding to a road or roads that are closed, and the model reroutes the traffic to the least-cost combination of alternative roads that are still open.

The model assumes that average speed is a function of traffic volume. It is assumed that the relationship between speed and traffic volume is linear such that average speed would be reduced to zero at a traffic volume of five times the current level. This assumption results in the model being a quadratic programming model as opposed to a linear programming model. When roads are lost in a flood scenario analysis, the model seeks the least cost route, but cost also increases as a function of congestion. Results of the model include a new total cost and change in traffic volumes by route.

Some preliminary results in terms of economic cost per day of outage under the current condition are shown in Table 21. Daily costs for the loss of Interstate 5 between highway 205 and 120 were estimated but they are believed to be highly inaccurate and are not shown. It is believed that the size of the network on Figure **7** is too small to capture many of the alternate routes that users of this reach would utilize.

Some preliminary results in terms of economic cost per day of outage under the current condition are shown in Table 21. Daily costs for the loss of Interstate 5 between highway 205 and 120 were estimated but they are believed to be highly inaccurate and are not shown. It is believed that the size of the network on Figure 7 is too small to capture many of the alternate routes that users of this reach would utilize.

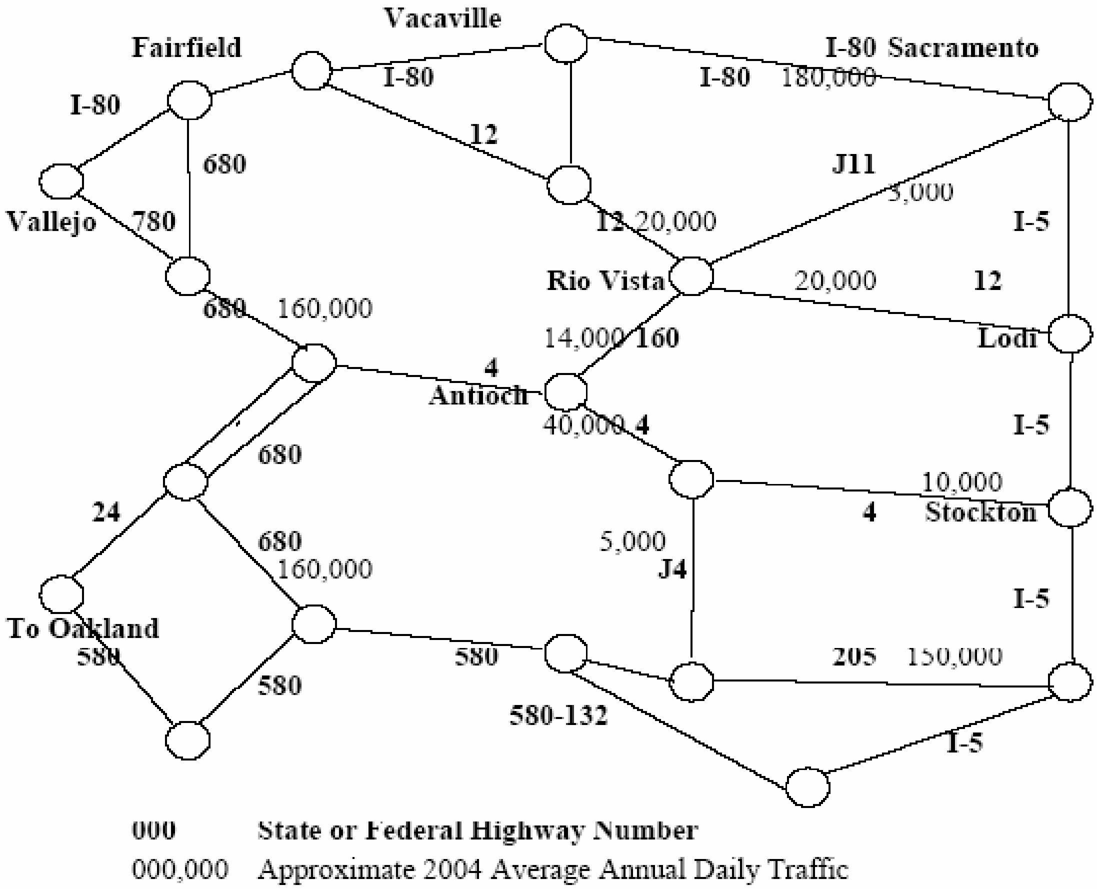

Figure 7 Network Diagram for DRMS Traffic Quadratic Programming Model – Not to Scale

Table 21
Preliminary Results of the Quadratic
Programming Model of the Delta Highway System

Highways Closed	Economic Cost per Day Million $
4	0.18
12	0.29
160	0.07
J11	0.06
4,12	0.71
4,160	2.08
4, J11	0.26
12, 160	0.36
12, J11	0.36
160, J11	0.11
4, 12, 160	2.32
4, 12, J11	2.37

The highway lost use analysis includes use of an existing model and database known as REDARS. REDARS is a modeling system used to assist Caltrans in making better investment decisions about road improvements, primarily in relation to earthquake damages. The model uses a national database of road system information to design a model that calculates increased use costs and lost trip costs associated with flooding of the principal State highways in the Delta. Running this model is time-consuming, so at this stage its use was minimized and restricted to calibrate against the assumptions used. REDARS assumes a cost of $13.45 per hour for automobile trips and $71.05 per hour for truck trips. Some results are provided in Table 22.

Comparison of the two methods shows that REDARS provides higher cost estimates than the QUADRATIC PROGRAMMING for the three individual road closures, even with the much lower cost per unit time, but a smaller cost for the three road closures combined. Possibly, the small scope of the quadratic programming model causes it to force too much traffic onto remaining routes when several roads are closed.

Table 22
Economic Loss Estimates for Six REDARS Scenarios

Scenario		Equivalent Time Delays per 24-Hour Day (pcu*hr)		Losses per 24-Hour Day (dollars)			Total Loss per Day assuming 10% are truck trips
Number	Road Closure	Travel Time Delays	Trips Foregone	Travel Time Delays	Trips Foregone	Total	
1	Route 4 from Byron Highway (J4) to Interstate 5	26,015	10,720	$349,902	$144,177	$494,079	$705,670
2	Route 12 from Route 160 to Interstate 5	13,811	2,442	$185,751	$32,845	$218,596	$312,211
3	Route 160 from Antioch Bridge to Route 12	9,119	small	$122,651	Small	$122,651	$175,176
4	All of the above	31,730	10,731	$426,762	$144,305	$571,067	$815,657
5	Close I-5 from Stockton at Highway 12 to J-11	129,234	479	$1,738,191	$6,346	$1,744,626	$2,491,787
6	Close I-5 from Junction I-205 to Junction 120	75,537	176	$1,015,973	$2,367	$1,018,340	$1,454,447

Table 23 shows recommended costs per day to apply for individual road closures and combinations. These values were developed by first estimating a cost per day for closures of the individual roads from results of the Quadratic Programming and REDARS. The costs for combinations of roads are the sum of the costs of the individual roads multiplied by a factor of 1.2, 1.4, 1.8, 2.2, and 3.0 if 2, 3, 4, 5, or all 6 roads are closed, respectively. These factors were developed by considering the cost increases from multiple road closures from the Quadratic Programming. Clearly, this method is meant to provide a gross approximation only; additional studies and modeling may be justified in the future.

Table 23
Adopted Daily Economic Costs for Combinations of Delta Road Closures

Highway Status						Recommended Cost per Day, Million $
4	12	160	205	J11	I-5	
Open	Open	Open	Open	Open	Open	$0.00
Closed	Open	Open	Open	Open	Open	$0.50
Open	Closed	Open	Open	Open	Open	$0.30
Closed	Closed	Open	Open	Open	Open	$0.96
Open	Open	Closed	Open	Open	Open	$0.12
Closed	Open	Closed	Open	Open	Open	$0.74
Open	Closed	Closed	Open	Open	Open	$0.50
Closed	Closed	Closed	Open	Open	Open	$1.29
Open	Open	Open	Closed	Open	Open	$4.00
Closed	Open	Open	Closed	Open	Open	$5.40
Open	Closed	Open	Closed	Open	Open	$5.16
Closed	Closed	Open	Closed	Open	Open	$6.72
Open	Open	Closed	Closed	Open	Open	$4.94
Closed	Open	Closed	Closed	Open	Open	$6.47
Open	Closed	Closed	Closed	Open	Open	$6.19
Closed	Closed	Closed	Closed	Open	Open	$8.86
Open	Open	Open	Open	Closed	Open	$0.10
Closed	Open	Open	Open	Closed	Open	$0.72
Open	Closed	Open	Open	Closed	Open	$0.48
Closed	Closed	Open	Open	Closed	Open	$1.26
Open	Open	Closed	Open	Closed	Open	$0.26
Closed	Open	Closed	Open	Closed	Open	$1.01
Open	Closed	Closed	Open	Closed	Open	$0.73
Closed	Closed	Closed	Open	Closed	Open	$1.84
Open	Open	Open	Closed	Closed	Open	$4.92
Closed	Open	Open	Closed	Closed	Open	$6.44
Open	Closed	Open	Closed	Closed	Open	$6.16
Closed	Closed	Open	Closed	Closed	Open	$8.82
Open	Open	Closed	Closed	Closed	Open	$5.91
Closed	Open	Closed	Closed	Closed	Open	$8.50
Open	Closed	Closed	Closed	Closed	Open	$8.14
Closed	Closed	Closed	Closed	Closed	Open	$11.04
Open	Open	Open	Open	Open	Closed	$3.00
Closed	Open	Open	Open	Open	Closed	$4.20
Open	Closed	Open	Open	Open	Closed	$3.96
Closed	Closed	Open	Open	Open	Closed	$5.32
Open	Open	Closed	Open	Open	Closed	$3.74
Open	Open	Closed	Open	Open	Closed	$4.79
Closed	Closed	Closed	Open	Open	Closed	$7.06
Open	Open	Open	Closed	Open	Closed	$7.20
Closed	Open	Open	Closed	Open	Closed	$10.50

Table 23
Adopted Daily Economic Costs for Combinations of Delta Road Closures

Highway Status						Recommended Cost per Day, Million $
4	12	160	205	J11	I-5	
Open	Closed	Open	Closed	Open	Closed	$10.22
Closed	Open	Closed	Open	Open	Closed	$5.07
Closed	Closed	Open	Closed	Open	Closed	$14.04
Open	Open	Closed	Closed	Open	Closed	$9.97
Closed	Open	Closed	Closed	Open	Closed	$13.72
Open	Closed	Closed	Closed	Open	Closed	$13.38
Closed	Closed	Closed	Closed	Open	Closed	$17.42
Open	Open	Open	Open	Closed	Closed	$3.72
Closed	Open	Open	Open	Closed	Closed	$5.04
Open	Closed	Open	Open	Closed	Closed	$4.76
Closed	Closed	Open	Open	Closed	Closed	$7.02
Open	Open	Closed	Open	Closed	Closed	$4.51
Closed	Open	Closed	Open	Closed	Closed	$6.70
Open	Closed	Closed	Open	Closed	Closed	$6.34
Closed	Closed	Closed	Open	Closed	Closed	$8.84
Open	Open	Open	Closed	Closed	Closed	$9.94
Closed	Open	Open	Closed	Closed	Closed	$13.68
Open	Closed	Open	Closed	Closed	Closed	$13.32
Closed	Closed	Open	Closed	Closed	Closed	$17.38
Open	Open	Closed	Closed	Closed	Closed	$13.00
Closed	Open	Closed	Closed	Closed	Closed	$16.98
Open	Closed	Closed	Closed	Closed	Closed	$16.54
Closed	Closed	Closed	Closed	Closed	Closed	$24.06

Natural Gas Transmission and Storage

PG&E operates backbone natural gas transmission and storage within the Delta. The company's largest natural gas storage field is located on MacDonald Island. PG&E operates the storage field by adding gas to storage during summer when demands are lower, and withdrawing gas during peak winter days when demand is highest. This storage is integral to ensuring winter gas supplies to Northern California. On a peak winter day natural gas from this storage location can supply as much as 20 to 25 percent of supplies needed in Northern California.

Currently PG&E is operating the storage through a single pipeline (designated 57B). Originally this pipeline was paralleled by an older pipeline (57A) with less capacity. However, PG&E has abandoned the part of the pipeline located in the inner Delta. Part of the older pipeline has been retained, and provides redundancy to help assure reliability.

On a regular basis PG&E reviews the status of its gas transmission system to ensure employee and public safety and investigate the local consequences of failure. For most of its system of pipelines, PG&E has judged that the societal cost of failures is insignificant because the duration of outages will be short and the effect on deliveries restricted.

However, PG&E has expressed a belief that the situation for Line 57B is unique. Failure of this line could result in an extended outage which could lead to widespread economic consequences.

Because of its concerns over the consequences of a disruption to Line 57B, PG&E is constructing Line 57C to parallel Line 57B where that pipeline is most at risk. This will reduce the risk of outage. To justify its investment in this line, PG&E conducted an investigation into the economic consequences of the failure of Line 57B. This showed that the major costs would result if the outage occurred in winter, and that the extent of those costs would depend on the system mean temperature at the time of the outage – the more extreme the temperature, the larger would be the resulting cost. PG&E reports the following estimates of costs, and the associated probabilities of occurrence of each temperature (PG&E 2005) (Figure 8).

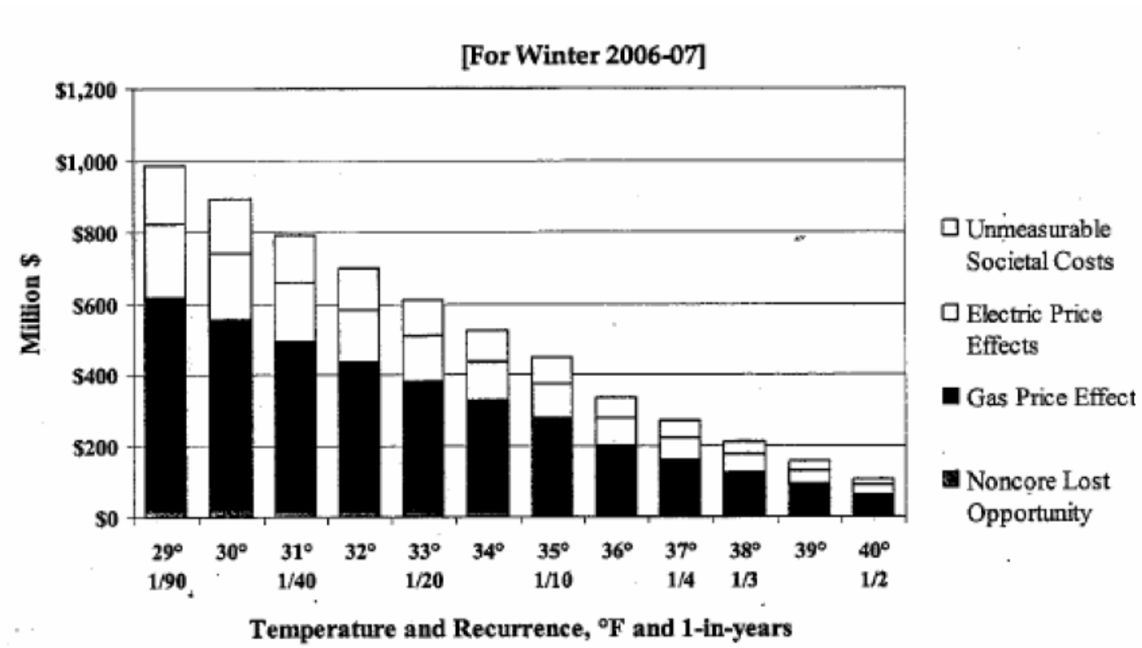

Figure 8 Line 57B Outage – Societal Cost Estimates per Occurrence

Although the construction of Line 57C reduces the probability of failure of pipelines servicing the MacDonald Island storage, it does not reduce the costs should such a disruption occur. We have therefore adopted PG&E's estimates of economic consequences. These are the consequences per winter of any gas pipeline failure during winter months of Lines 57B and/or 57C that results in an inability to transfer natural gas from the Macdonald Island storage.

So long as the pipelines are operational, and flooding is not protracted, PG&E is not so concerned about the operation of the storage field on Macdonald Island. In 1982 McDonald Island flooded yet the storage system was able to operate throughout the period the island was flooded, albeit at a suboptimal level (Moss 2007). However, with a more extended outage, continued operations become more problematic. While PG&E can operate the natural gas storage facility while the island is flooded, they cannot maintain it in such a condition. As a result, an extended flood would lead to operational safety concerns that could require the facility to be shut down. While this would have some limited cost effects in all months, the major costs would be incurred over winter months, where the effect would be the same as if pipelines 57 B and C were both to fail.

For the analysis of economic costs, cost effects were assumed to occur only in winter months. In addition, no economic costs were assumed to occur as a result of flooding for 6 months or less. After that time, the storage facility was assumed closed, and costs were assumed incurred in every winter month of flooding after the initial six months. Based on PG&E's analysis, the estimated cost of loss of the use of the natural gas storage is $114.4 million per winter month.

Oil and Gas Wells

Natural gas production is an important economic activity within the Delta. Most natural gas production is not covered in the business sales analysis because most of the companies that own the gas wells are not located within the analysis zones. In a flood event, owners of the gas wells will shut them off if possible. Wells that cannot be shut off may be permanently lost. For this analysis, it is assumed that wells can be shut off before flooding, and that production can resume after a flooding event.

The analysis uses two databases from the California Department of Conservation. One database provides a listing of all wells in Division 6 and their location. Division 6 includes most of northern California. This database was used to place all of the wells into the study area, and those within the study area were placed into analysis zones. Most of these wells, however, are not currently producing. Another database provides production of each well in 2004 and 2005. Those wells that did not produce in 2004 or 2005 were excluded from the analysis and average production for the remaining wells in each analysis zone were summed to obtain total production by analysis zone.

Table 24 shows gas production and value by analysis zone for 2004 and 2005. About 240 wells were producing in 2004 and 2005. The value of production per day at a price of $5.46 per thousand cubic feet (Energy Information Agency 2005) is estimated to be $871,000. Although the total value of natural gas production is reported, it is extremely unlikely that a single event would cause the loss of all natural gas production.

The economic cost of gas production outages is not the same as the lost revenue from lost production for three reasons:

1. The variable cost of gas production is avoided when production stops
2. Some of the lost sales will be made up by production elsewhere in the state
3. The gas that is not extracted during the outage can be extracted later

Natural gas requires a cost to produce, but industry cost information and budgets suggest that much of this cost does not vary with the amount of natural gas produced (Delta Petroleum Corporation 2004; USDC 2002). The variable cost of gas production is assumed to be 10% of sales revenues. It is further assumed that the lost sales would not be made up by increases in production elsewhere in the state.

Flooding causes natural gas production to be lost, but not forever. It is assumed that production lost during an outage can be obtained later by increased production per well, by drilling new wells, or simply by extending the productive life of the well. The average time required to make up the lost production is assumed to be 5 years. The net value lost at the time of the flood is the current net value of production, minus the future net value of production, but the future net value must be discounted to the present.

After accounting for variable costs and the 5-year delay at a 6 percent state discount rate, 23 percent of the current value of gas production is lost by delaying its production by five years. That is, the economic cost per day of lost use of wells is equal to the last column of Table 19 times 23 percent. This estimate does not include any additional repair, restoration, or drilling costs that may be caused by flooding.

Table 24
Summary of Natural Gas-Producing Wells and Production by Analysis Zone, 2004 and 2005, in Order of Average Dollar Value of Production Per Day

Analysis Zone Name	2005 Production mcf[1.]	2005 Number of producing wells	2004 Production mcf [1]	2004 Number of producing wells	Mil $ gross value of production per day, 2004 and 2005[2.]
McDonald_Tract	34,084,609	69	38,808,407	69	$0.5452
Brannan-Andrus Island	5,117,858	33	8,499,520	33	$0.1019
Twitchell_Island	2,672,959	9	3,932,994	9	$0.0494
Zone 70	2,082,197	30	3,007,402	33	$0.0381
Union_Island 1	1,469,947	8	1,579,767	7	$0.0228
RD 17 Mossdale	1,344,390	4	685,106	3	$0.0152
Netherlands 3	990,067	3	568,932	2	$0.0117
Tyler_Island 2	1,244,520	9	311,499	9	$0.0116
Roberts_Island 1	566,664	6	842,354	7	$0.0105
Moore Tract 2	317,030	4	672,701	5	$0.0074
Zone 80	663,839	2	166,658	2	$0.0062
Grand Island	503,627	6	285,185	4	$0.0059
Water Zone 2	370,563	4	393,013	4	$0.0057
Roberts_Island 4	323,004	6	301,473	6	$0.0047
Ryer Island	183,079	2	438,104	3	$0.0046
Staten_Island	199,154	3	349,388	2	$0.0041
Hotchkiss_Tract 1	173,189	5	202,048	7	$0.0028
Bethel_Island	177,999	3	167,405	4	$0.0026
Peter Pocket	129,900	3	168,247	4	$0.0022
Hastings_Tract 2	105,093	4	180,198	5	$0.0021
Jones_Tract	129,310	1	143,477	1	$0.0020
Jersey_Island	147,376	3	103,480	4	$0.0019
New_Hope_Tract	30,576	1	218,049	3	$0.0019
King_Island	55,142	2	171,405	1	$0.0017
Webb_Tract	77,938	2	142,739	2	$0.0017
Moore Tract 3	129,867	3	67,518	2	$0.0015
Sherman_Island	91,307	1	104,048	1	$0.0015
Zone 74	60,812	1	58,245	2	$0.0009
Moore Tract 1	33,378	1	50,713	1	$0.0006
Van_Sickle_Island	37,922	4	37,762	4	$0.0006
Zone 81	23,608	1	37,670	1	$0.0005

Table 24
Summary of Natural Gas-Producing Wells and Production by Analysis Zone, 2004 and 2005, in Order of Average Dollar Value of Production Per Day

Analysis Zone Name	2005 Production mcf[1.]	2005 Number of producing wells	2004 Production mcf [1]	2004 Number of producing wells	Mil $ gross value of production per day, 2004 and 2005[2.]
Zone 68	28,462	1	24,519	1	$0.0004
Rindge_Tract	47,909	4	0	0	$0.0004
Brack_Tract	18,489	1	29,025	1	$0.0004
Zone 214	10,447	1	19,534	1	$0.0002
Zone 120	6,849	1	9,243	1	$0.0001
TOTAL	53,649,080	241	62,777,828	244	$0.8708

[1] mcf = thousand cubic feet
[2] Based on wellhead price of $5.46 per mcf

Petroleum Products Pipelines

Kinder Morgan Energy Partners (KMEP) owns and/or operates a number of "product" pipelines that cross the Delta. To date we have not identified the location of these pipelines, but we believe they include all or most of the following:

- KMEP Concord to Stockton and Bradshaw 10"/8" pipeline
- KMEP Concord to Sacramento and Rocklin 14" and 12" pipeline (connects to Reno and Chico pipeline systems, and serves the Naval Air Station at Fallon, NV)
- KMEP Concord to Fresno 12" pipeline
- KMEP Concord to Suisun 8" pipeline (serves Travis Air Force Base)
- Navy Concord to Ozol 8" pipeline.

(Kinder Morgan 2006)

These pipelines are estimated to provide approximately 50 percent of transportation fuels to Northern California, and are a major source of supply to northern Nevada. As can be seen from the list, failure of these pipelines will also be a national security concern because the pipelines provide aviation fuel to these military bases (Schremp 2006).

The pipelines are generally around 4 feet below the soil surface, and have remote electronic valves so they can be shut down fast in times of emergencies. They also have an operating practice of pumping out oil and filling with water if the pipeline site is flooded (Blurton 2006). This keeps the lines weighted to minimize spill in case of rupture.

Kinder Morgan staff report that although they do not own the products shipped through their lines and are not responsible for maintaining a storage buffer, their customers typically maintain enough supplies to maintain services for an outage of a few days. Past pipeline ruptures in California have been of single pipelines and have been repaired in a few days, including some times under water (Englehart 2007). To date there has been no supply shortage in California that resulted from a pipeline rupture, but in the past, fuel price "spikes" have been caused by extended outages in refineries. If multiple pipelines were to fail, or pipelines were to fail in multiple places, supply problems could arise (California Energy Commission 2006).

An extended disruption occurred in a pipeline between Phoenix and Tucson in August 2003. This was one of two pipelines supplying the Phoenix area, and was out of service for approximately 2 weeks. During that time tanker trucks transported fuel from Tucson to Phoenix. An investigation into this incident found that fuel prices increased by approximately 25 percent during the disruption, and that the shortage, exacerbated by panic buying, caused long lines at service stations. The increased number of tanker trucks created bottlenecks at the loading terminals in Tucson. As a result, trucks spent as long as seven hours waiting to be filled, instead of the usual time of approximately 30 minutes. Combined with the additional travel time, the additional filling time resulted in the need for approximately 4 times the normal number of trucks to maintain supply levels (Essential Services Task Force 2004).

It is estimated that the Kinder Morgan disruption in Arizona caused little change in revenues, because approximately the same level of product was delivered, although the time taken was longer. Losses appeared to be concentrated on pipeline repair and environmental cleanup.

The situation in California would likely be of less concern than that in Arizona. Northern California has a multiplicity of product pipelines, rather than relying on just two as is the case for Phoenix. The California Energy Commission has developed a plan to respond to fuel disruption from earthquake that would rely on extensive use of tanker trucks, as was the case in Phoenix (Schremp 2006).

Thus, while the disruption of Kinder Morgan pipelines could cause economic disruption, much of it would be in the form of transfers of wealth from gasoline buyers to trucking firms and gasoline supply companies, rather than a reduction in overall economic activities. The major economic cost would be the increase in transportation costs caused by switching from pipelines to trucking.

Over time, the California Energy Commission hopes that petroleum product infrastructure improvements will concentrate on increased investment in storage, to allow greater flexibility to deal with disruptions in the supply system however they occur (California Energy Commission 2003). They also expect that growing demands in California will be met at least in part by Nevada and Arizona developing other sources of supply (notably, pipelines from Texas). The recent infrastructure report did not address a need for additional pipeline investments, although as the pipelines are owned by private companies, any such planning would not be public knowledge.

In addition to potential supply impacts for Northern California, northern Nevada would be seriously affected. This region receives nearly 100 percent of their transportation fuel supply from the Kinder Morgan pipeline (Schremp 2007). The Fallon Naval Air Station is also supplied through these pipelines. However, these costs would fall outside of the state and so should not be considered in this analysis.

California Energy Commission staff considered a scenario in which two of these pipelines were placed out of service:

- Concord-Stockton-Sacramento (Bradshaw)
- Concord-West Sacramento-Chico & Reno.

The location of these pipelines is shown on Figure 9. Energy Commission analysts estimated that loss of these pipelines could cost California consumers at least $25 million per day in higher gasoline prices (Schremp 2007). This is the cost to the gasoline consumer, and is greater than the cost to the state because it includes transfer payments

from the consumers to the truck drivers that will transport the gasoline. No estimate of the economic costs was obtained for this infrastructure.

Railroads
Three major railroads cross the Delta. These railroads carry freight and passenger service. The railroads are described below.

The Union Pacific railroad from Oakland to Sacramento. This railroad carries both freight and the Capital Corridors passenger service.

- The passenger service is estimated to consist of 32 intercity (San Jose to Sacramento and return) trains plus four long-distance trains per day. This is an estimated total of 325 cars per day, with 1.3 million passengers per year. The service is estimated to reduce the number of vehicle miles traveled on the road between San Jose and Sacramento by 100 million per year. Capitol Corridors is the managing agency, and obtains 50 percent of its funding from the state, with a further 50 percent obtained from fares paid. The annual revenues are approximately $46 million, or $126,000 per day (Skaoropowski 2006).
- The freight service ships a mixture of automotive and intermodal service (ship to train) from ports in the Bay Area. There are approximately 17 of these per day, with 75 to 100 cars per train (Wickersham 2006). This is assumed to be approximately 1500 box cars per day.

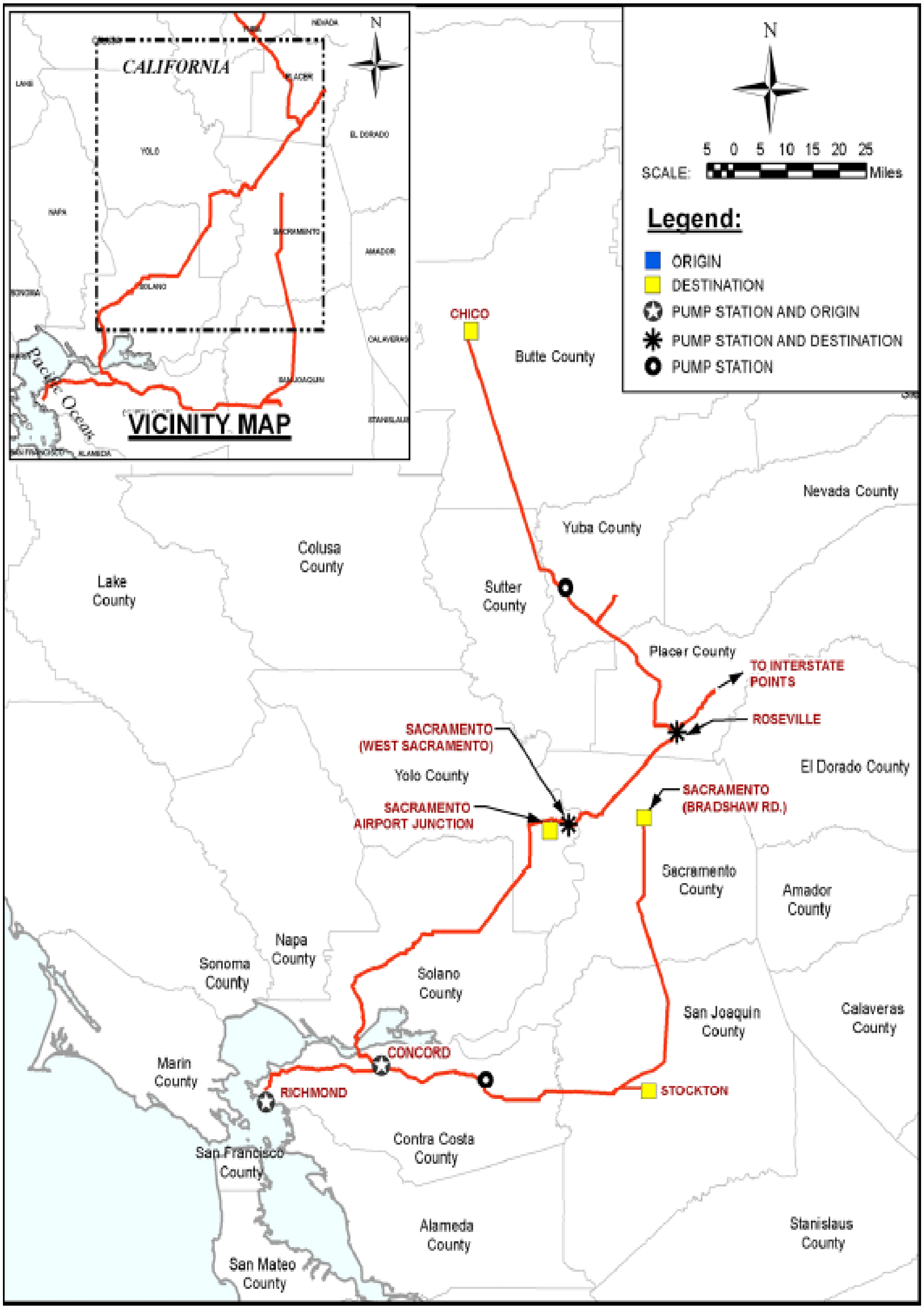

Figure 9 Location of Major Kinder Morgan Pipelines

The Union Pacific railroad from Fremont to Stockton. This railroad carries 11 trains per day. Six of these are passenger, and 5 are freight. The freight service ships automobiles from the Fremont New United Motor Manufacturing Inc. plant, other automobile, intermodal container freight, and other general freight (ibid). This is assumed to be approximately 500 railroad cars per day. The passenger service is assumed to be funded at the same level and proportion as that on the Union Pacific railroad between Oakland and Sacramento.

The Burlington-Northern and Santa Fe Railroad (BNSF) railroad to Stockton. Because of the current law suit related to the flooding of Jones Tract, BNSF lawyers instructed their employees not to respond to questions related to the costs of interruption to railroad service across the Delta. The BNSF railroad to Stockton is a major freight line, so we have assumed that the revenues related to freight shipments on this line are the same as those estimated for the Union Pacific railroad from Oakland to Sacramento.

In addition, Amtrak operates an intercity passenger service on this railroad. The passenger service runs from Oakland through Port Chicago to Stockton. There are 8 passenger trains (4 round trips), with annual farebox revenues of $27 million, and a similar amount from the state (Bronte 2007). These revenues are $146,000 per day.

Economic Losses from Freight Transportation

The economic losses associated with the loss of freight transportation is measured by the increased costs of using a less efficient alternative form of transportation. In this case, it has been assumed that the same freight would travel by truck across the Delta and be loaded on trains either in Stockton or Sacramento. This would add considerably to the number of trucks on Northern California highways. BNSF estimates that its average intermodal train moves the equivalent of 220 trucks (BNSF 2006). This suggests that closure of one of the major railway lines could result in an additional 3,700 trucks per day on the highways around the Delta. As discussed in the section on petroleum products pipelines, it is not clear whether the necessary number of trucks could be found to meet these requirements.

A comparison of truck and rail transportation costs obtained from Caltrans gives the following cost comparison for freight transportation from San Francisco to Reno Nevada (Caltrans 2001).

Trucking,	$24.79 per ton
Rail	$7.74 per ton

These numbers were inflated to 2005 values using industry cost indexes from the Bureau of Labor Statistics (2007). These estimates are also for a distance of 219 miles. To obtain costs for the three railroads crossing the Delta, these costs were deflated by the assumed mileage estimates between the start and end points of each railroad. The mileages assumed, and the resulting costs per railroad are provided in Table 25. The differences between these costs were then multiplied by an assumed 61.3 tons of freight per railroad car (Association of American Railroads 2005), and the estimated number of railcars described above, to result in the estimates of increased costs per day reported in Table 25.

There are a number of issues with this procedure. First, the mileage given is road miles for both road and rail prices. In fact, rail distances may be longer than road miles.

Second, the reduction of the cost by the ratio of mileages is not strictly appropriate, because railways are less competitive with trucks over shorter distances. However, this was the most appropriate measure that has been found to date. Third, it assumes that no additional loading and unloading is required – that the trucks that had previously taken goods from their source to, for example, the Oakland freight yards to load on the railway would merely continue on to Sacramento instead. To the extent that these goods are shipped by rail to the Oakland, rather than by truck, and additional loading and unloading would be required. This would increase the costs shown here.

Table 25
Economic Costs per Day – Rail Freight

	Union Pacific Oakland to Sacramento	Union Pacific Fremont to Stockton	BNSF Oakland to Stockton
Mileage	82	67	80
Cost per ton (truck)	$10.62	$8.68	$10.37
Cost per ton (rail)	$3.46	$2.83	$3.38
Difference	$7.16	$5.85	$6.99
Tons per railcar	61.3	61.3	61.3
Railcars per day	1500	500	1500
Increased costs	$658,000	$179,000	$642,000

The above estimates do not include the lost income to the railroad companies. While this would be a cost to those companies, it would not be a cost to the state. The lost income would be largely gained by the trucking companies that increased their shipping revenues because of the assumed shift from rail to truck.

Economic Costs From Interruption to Intercity Commuter Rail

The economic costs from interruption to the intercity commuter rail services (Capitol Corridors and Altamont Commuter Express) come in two forms: The loss of consumer surplus of those individuals who wish to ride the trains but cannot, and the increased congestion costs borne by all travelers on the highways around the Delta as the train commuters changed to their cars.

These amounts have not yet been estimated. However, the state subsidy for the intercity rail services has be used as a proxy for the increased congestion costs, and the fare income as a proxy for the lost consumer surplus. These are not good estimates, and should be replaced if more appropriate estimates can be developed. The current estimated economic costs are presented in Table 26.

Table 26
Economic Consequences Per Day – Intercity Passenger Rail

	Union Pacific Oakland to Sacramento	Union Pacific Fremont to Stockton	BNSF Oakland to Stockton
Increased congestion cost	$62,000	12,312	73,000
Lost consumer surplus	$62,000	12,313	73,000
Economic losses	$124,000	$23,625	$146,000

Future Growth

There is every indication that the level of traffic on these lines will increase in the future. The Metropolitan Transport Commission forecasts that container traffic tonnage at San Francisco area ports (largely Oakland and Richmond) is expected to increase by 5 percent per year through 2030 (Metropolitan Transport Commission 2004). The passenger train routes are continuing to grow as population growth moves out of the Bay Area into surrounding counties. Highway congestion, coupled with the movement of warehousing and trucking operations to the Central Valley, has prompted planning for short-haul rail services that would use existing rail assets to link the Port of Oakland to those trucking locations (the California InterRegional Intermodal System, or CIRIS [Tioga 2006a]). However, the Bay Area section of the state's Goods Movement Action Plan concentrates largely on improving highway traffic flows.[11] In this plan, the majority of rail investments are projected for the Los Angeles area. The Sacramento Area Council of Governments forecasts that rail cars into and through Sacramento will grow by 1.9 percent per year from 2003 through 2020 (Tioga 2006b). In all, the growth in the value of operating income to be lost would likely be in the area of 2 percent per year.

Wastewater Facilities

FEMA (2005) provides a simple method for calculating costs from loss of wastewater services. $33.50 per capita per day is assumed for complete loss of treatment and $8.50 per day for partial loss of treatment. Data requirements are the number of persons affected and days without service.

Inspection of GIS data on wastewater facilities in the Delta determined that a number of facilities might be affected by levee failures. As part of the DRMS effort, a survey of wastewater plants that might be shut down by Delta levee failures was conducted. The survey found that some facilities located in the floodplain are protected by levees on-site, and others are scheduled to be relocated or combined into regional wastewater service soon. Information for facilities that could be affected is provided below.

City of Stockton wastewater treatment facilities are located on Zone 159 and Roberts Island in 100-year floodplain. The primary and secondary treatment facility is on the east side (Zone 159) and the tertiary facility is on the west side (Roberts Island) of the river (Gharegozloo 2006). Protection is by the San Joaquin River levees; there are no additional levees around the facilities. If the tertiary facility was lost they would probably

[11] California Business, Transportation and Housing Agency and California Environmental Protection Agency, *Goods Movement Action Plan Phase I: Foundations,* September 2005.

discharge secondary-treated water to the river rather than stop service. About 280,000 people are served of which about 10,000 live in Zone 159. Therefore, if Zone 159 floods, the cost per day of lost service is $9.0 million ($33.50 times 270,000). If Roberts Island floods, especially in an event not related to high river flows, the release of secondary treated effluent to the San Joaquin River may impair the ability to use Delta water for other purposes.

<u>Ironhouse Sanitation District</u> has its own levee system (Skrel 2006). The facility is on the mainland south of Big Break. They own about 95% of Jersey Island which is used for wastewater disposal. If Jersey Island were lost, they could store wastewater in ponds temporarily; in wet conditions, perhaps 2 days to a week; in dry conditions, several weeks to 2 months. They provide service for about 30,000 people, Therefore, if Jersey island floods for more than a week (wet conditions), or more than a month (dry conditions) then 30,000 people would lose wastewater service at a cost of $1 million per day ($33.50 times 30,000). About 2,300 customers are on Bethel Island. If Bethel Island also floods, the daily cost would be reduced to $0.93 million. However, these costs are assumed to no longer be a factor after 2010, when regulatory requirements will require treatment such that the wastewater can be discharged directly into the Delta in emergency situations.

<u>Rio Vista ‘s</u> existing facility is next to the Sacramento River and serves about 2,000 people now (McAuliffe 2006). A new treatment facility far from the river will replace the old one before 2030. In the past they have built a 2 ft berm along the river side to keep protect the facility. This new facility is not in an Analysis Zone, so the costs are not included in the estimates.

<u>The City of Isleton</u> wastewater treatment facility is located in the 100-year floodplain on Brannan-Andrus Island (Henricks 2006). About 310 connections are served; 330 more are expected. If flooded, about 1,500 persons would lose service at a cost of $50,000 per day.

<u>The Sacramento Combined Wastewater Treatment Plant</u> is located in Zones 76 and 196. The plant serves about 1,000,000 persons. The plant is protected by a ring levee system which was raised from 18 to 22 feet in about 1999 (Carollo Engineers 2000). The plant would flood only if the ring levee system failed. If Zone 76 and 196 also flooded then approximately 200,000 persons would be relocated, so 800,000 could be affected by the loss of wastewater service only. Cost per day of outage would then be $26.8 million. The costs to any other customers who have been evacuated from the region should also not be included. We assume, if Zone 76 and Zone 196 flood, the ring levee system will not be affected.

Table 27 summarizes this information.

Table 27
Summary of Economic Costs Associated with Lost Use of Wastewater Facilities

Facility	Analysis Zone	Cost/Day of Outage	When Cost Incurred
City of Stockton	Zone 159	$9,000,000 or less	Immediately when flooded
City of Stockton	Roberts Island	? Discharge of secondary treated effluent to the Delta	Immediately when flooded
Ironhouse	Jersey Island	$930,000	After 1 week in winter, 1 month in summer
City of Isleton	Brannan Andrus	$50,000	About ½ is a new subdivision
City of Sacramento	Zone 76, 196	$26,800,000 or less	Only if the existing ring levee fails (22 feet)

2.1.7 Changed Reservoir Operations

Electricity Generation and Use

When the operation of the water supply system is interrupted, hydroelectric generation will be changed. For the upstream reservoirs, hydroelectric generation could be increased or decreased, depending on the use of that water for flushing salt from the Delta. For export project operations south of the Delta, both pumping loads and hydroelectric generation will be reduced, as less water will be pumped to the contractors.

Recreation

This section describes the model and data that will be used to estimate losses in consumer surplus from reductions in reservoir recreation due to changed reservoir operations.

Model Premise

Extensive damage to Delta levees may require re-operation of SWP, CVP, and other surface water reservoirs. Re-operation, in turn, may reduce the amount of water in storage, lower surface water elevations and impair opportunities for surface water recreation. Prior research has associated changes in surface water recreation with changes in reservoir surface area. Lawrence Berkeley National Laboratory (LBNL 2006) utilized this information to develop a model that estimates the change in recreation benefit for a given change in reservoir storage. The model can be implemented for 21 major surface water reservoirs in California, including those most likely to be impacted by levee failure in the Delta.

Model Equations

Presentation of the model draws heavily from the work done by LBNL. The relationship between reservoir area and reservoir volume can be approximated by a power law of the form:

(1) $A = cS^p$

where A is the area, S the storage, and c and p are constants that depend on the reservoir. This type of function is used in the CALSIM II model of the CVP-SWP system. From this equation, a change in storage ΔS induces a change in area ΔA with:

(2) $$\Delta A = c\left[(S + \Delta S)^{p} - S^{p}\right]$$

Define the coefficient of elasticity of visitor-days to reservoir surface area, e, as

(3) $$e = \frac{\Delta U / U}{\Delta A / A}$$

Rearranging terms in equation (3) gives

(4) $$\Delta U = e\frac{U}{A}\Delta A$$

Substituting equation (2) into equation (4) gives

(5) $$\Delta U = eU\left[\frac{(S + \Delta S)^{P}}{S^{p}} - 1\right]$$

Equation (5) allows us to calculate the change in visitor-days for a given change in reservoir storage. Letting V stand for the user benefit of a visitor-day, the change in user benefits from a change in storage is:

(6) $$\Delta UB = eU\left[\frac{(S + \Delta S)^{P}}{S^{p}} - 1\right]V$$

To allow the model to estimate changes in user benefits caused by monthly changes in storage, annual visitor days are distributed across the months of the year and the model becomes:

(7) $$\Delta UB_{m} = f_{m}eU\left[\frac{(S_{m} + \Delta S_{m})^{P}}{S_{m}^{\ p}} - 1\right]V$$

where the subscript m denotes the month of the year and f_m is the fraction of annual visitor-days occurring in month m.

Model Data

LBNL estimated the parameter p for 25 reservoirs using data available from the CALSIM II model. The surface area elasticity of visitor-days is set to 0.9 for all reservoirs. The basis for this assumption is described in LBNL.

Values for V and U, drawn from Mitchell and Wade (1991), are available for 21 of the 25 reservoirs for which LBNL estimated p values. All dollar values are updated to 2005 constant dollars.

The monthly parameters, f_m, are from LBNL. Wade et al. (1989) provide a disaggregation of annual visitation over months for several major reservoirs. LBNL notes about 70% of recreation use occurred in the months May through September, and monthly variation within each major period was not large. LBNL therefore set the parameters, f_m, as follows:

$$(8) \qquad f_m = \begin{cases} 0.14 \text{ if m} = \text{may, jun, jul, aug, sep} \\ 0.043 \text{ if m} = \text{oct, nov, dec, jan, feb, mar, apr} \end{cases}$$

Monthly reservoir storage, S_m, for the period 1970–2005 was taken from the California Data Exchange Center website. This data was used to calculate average monthly storage for the 21 reservoirs by year type. Four year-types were used: (1) critically dry, (2) dry or below normal, (3) above normal or wet, and (4) average for all years.

Annual visitation estimates, U, taken from Mitchell and Wade were assumed to apply to average storage conditions. Baseline annual visitation for the three other year-type categories were calculated using equation (5) as follows:

$$(9) \qquad U_{i,m} = U_m + f_m eU\left[\frac{(S_m + \Delta S_{i,m})^P}{S_m{}^p} - 1\right]$$

where $U_{i,m}$ denotes baseline monthly visitor-days for year-type i and month m, U_m is baseline visitor-days for the average year condition, S_m is monthly storage for the average year condition, and $\Delta S_{i,m}$ is the difference in monthly storage between year-type i and the average year condition.

The final form of the model for year type i is therefore:

$$(10) \qquad \Delta UB_{i,m} = eU_{i,m}\left[\frac{(S_{i,m} + \Delta S_m)^P}{S_{i,m}{}^p} - 1\right]V$$

Running the Model

Running the model requires specifying changes in monthly storage for each reservoir affected by a levee failure scenario. Changes in storage must be expressed relative to the baseline storage condition.

2.2 Economic Impacts

The economic impact analysis provides measures of total economic impacts (as opposed to economic cost) for the state. The measures are:

- value of output,
- employment,
- labor income (wages and salaries), and
- value added (labor income plus proprietor's income plus other property income plus indirect business taxes)

The estimates are "total" in that they include reduced economic activity through backwards economic linkages. These linkages represent the purchases by affected businesses and households in the California economy. For example, if field crops are flooded, they will purchase less chemicals, labor and energy for crop production, and these businesses in turn reduce their purchases, and so on.

Input-output (I-O) models estimate the effect of backwards trade linkages associated with a direct change in output. The direct loss of sales causes an equal reduction in purchases by these businesses, and the share of these purchases that are from California businesses represent an additional loss of California sales. This effect continues through additional backwards linkages. The total effect is limited by the share of purchases that are imports into California.

I-O uses information on sales and expenditures by industry, including the share of expenditures bought from in-state businesses, to estimate economic multipliers. The multipliers can be used to estimate the total economic impact per dollar of direct output reduction for any industry. For example, the ratio of the total loss of sales to the direct loss is the output multiplier.

IMPLAN is an I-O modeling package and database for 519 industries that can be used to develop an I-O model of any county-level or larger economy. For this analysis, 2004 data for every county in California were used to develop a state I-O database and model. The I-O model provides information on how direct sales losses caused by flooding affect the rest of the state economy through the backwards trade linkages.

IMPLAN provides data on employment, wage and salary income, other income, and value added, and multipliers for these measures can be used to estimate the total effect on these other economic measures. For this analysis, since the ESRI data provides employment in the Delta, the ESRI data are used to estimate that part of the direct employment effect, but IMPLAN multipliers are used to estimate the total employment effect.

Data from the 2004 IMPLAN database are summarized in Table 28.

The IMPLAN data are available for 2004 and earlier years. To predict 2030 values, economic forecasts from Woods and Poole Economics (2006) are used. The ratio of 2030 to 2004 employment from the Woods and Poole analysis set, times 2004 IMPLAN employment, are used to project 2030 IMPLAN employment. The ratio of 2030 to 2004 Woods and Poole earnings are used to project 2030 IMPLAN value of output. Data used in this analysis are provided in Table 29 and projections to 2030 are provided in Table 30. IMPLAN 2004 data and multipliers are provided in Appendix G.

Economic impacts are calculated from the state perspective using the state model. The direct effects arise from the following:

In the Delta

- Lost business sales
- Lost agricultural production
- Delayed natural gas production
- Reduced recreation expenditures

From reduced water supply

- Reduced value of industrial output in the south Bay and south coast
- Reduced value of agricultural output in the San Joaquin Valley

The following effects are not counted:

- Federal disaster aid or payments
- Expenditure of insurance payments or other reconstruction expenditures

Economic Impacts from Direct Effects in the Delta

The economic impacts from lost business sales were discussed above. In summary, business sales in the Delta are lost, but some of these sales are picked up by other businesses in-state. The net direct effect considers this substitution effect. The direct effect on output and employment is based on data in the ESRI database. The IMPLAN multipliers are used to calculate total effects on output, employment, labor income and total value added.

The analysis of output losses for in-Delta agriculture provides the basis for the impact analysis. Output losses occur because of flooding and because of water quality effects. Direct value of output losses are inputs to the I-O analysis. The analysis considers the share of agricultural purchases that would have occurred from businesses that are flooded. That is, output losses that occur because agricultural suppliers are flooded, or because farmers don’t buy inputs from them, are not double counted.

There is no analysis included for natural gas. Little of the cost of natural gas production is for variable inputs, so the reduced gas production during a flood has a minimal effect on expenditures. Furthermore, it has been assumed that the gas production will resume and be recovered later. Therefore, and reduced spending during a flood will be offset by increased spending later.

The analysis of expenditure losses for in-Delta recreation provides the basis for the impact analysis. Direct value of expenditure reductions are inputs to the I-O analysis. The analysis considers the share of expenditure reductions that would have occurred from businesses that are flooded. That is, output losses that occur because marinas, resorts and hotels are flooded, or because recreationists don’t buy inputs from them, are not double counted.

Economic Impacts from Reduced Water Supply

The economic impacts of reduced agricultural production were estimated based on the change in agricultural production resulting from the reduction in SOD agricultural water supply. This estimate reflects the change in employment, farm proprietor and labor income that would result from a decrease in agricultural production by major crop type. It also reflects the reduction in sales of farm inputs, such as farm machinery, seeds pesticides and fertilizer, and agricultural services.

As part of the analysis of water supply shortages to urban agencies, the level of shortage to urban industries is calculated for agencies in 5 Bay Area counties and 6 counties in Southern California. This was then converted to a percentage reduction in industrial output for each of these agencies, using the model described in Appendix G.

However, some agencies cross county lines, so where necessary, the population in those agencies were apportioned between counties. The estimated population within each county that is served by one of the studied agencies was then compared with estimates developed by the Demographic Research Unit of the Department of Finance. The percentage of total county population served by agencies operating within those counties was calculated, and is provided in Appendix G. These percentages were used to develop a weighted average percentage reduction in county manufacturing output.

The percentage reductions were used in conjunction with the IMPLAN model to develop an estimate of the economic impacts resulting from the urban water supply shortages.

This approach has a number of limitations. First, it assumes that the major regions of economic impact to industry through changes in water supply are felt in the eleven counties that are analyzed. While these counties are the major industrial counties in the state, this will result in an underestimate of the total impacts because we have not included a number of counties with smaller industrial bases were not included. Second, industrial output within a county is assumed spread between the agencies serving those counties according to the population served by each agency. This may be incorrect, because one agency may serve the suburbs of a county, while the other serves the industrial base, but this was the only way to recognize water supply differences within a county.

Table 28
California Output, Employment and Value Added from IMPLAN 2004 Database

Aggregated Sector Name	Industry Output*	Employment	Employee Compensation*	Proprietor Income*	Other Property Income*	Indirect Business Tax*	Total Value Added*
Crops	$29,279	207,131	$4,726	$6,932	$7,598	$559	$19,815
Livestock and Dairy	$18,881	83,773	$1,617	$255	$1,259	$292	$3,424
Other Ag For Fish	$9,924	231,784	$4,887	$1,028	($271)	$115	$5,758
Oil and Gas	$10,869	23,209	$1,515	$671	$3,271	$605	$6,061
Mining	$2,526	14,245	$830	$48	$803	$94	$1,776
Construction	$209,059	1,327,422	$58,588	$22,046	$21,565	$6,046	$108,245
Manufacturing	$574,689	1,560,869	$110,635	$5,915	$37,159	$5,366	$159,074
Wholesale, transportation, storage	$196,013	1,378,483	$71,034	$8,771	$25,696	$21,532	$127,033
Retail	$150,380	1,900,343	$53,734	$8,830	$15,329	$20,776	$98,670
Publishing, communications, IT	$190,711	543,710	$45,971	$8,635	$37,121	$6,270	$97,997
Finance, Insurance, RE, rentals	$371,485	1,851,291	$75,234	$27,340	$113,635	$24,552	$240,762
Schools and Education	$17,829	344,543	$9,647	$370	$681	$194	$10,893
Medical and Social	$137,514	1,636,430	$64,594	$11,332	$10,563	$1,044	$87,533
Entertainment	$34,314	496,878	$13,055	$2,783	$4,225	$1,859	$21,922
Accommodations and Restaurants	$77,614	1,408,167	$25,744	$1,796	$8,691	$4,859	$41,091
Car, Repair and Pers. Services	$67,922	713,226	$15,630	$6,486	$12,355	$4,155	$38,626
Other Services	$319,705	3,218,911	$144,234	$33,489	$21,661	$3,634	$203,018
Religious & Civic	$14,982	292,035	$9,228	$73	($2,827)	$29	$6,504
Other	$315,254	2,824,673	$164,595	$0	$99,978	$13,483	$278,056
	$2,748,950	20,057,121	$875,496	$146,802	$418,493	$115,465	$1,556,255

*Millions of dollars

Table 29
California Employment and Earnings Estimates for 2004 and 2030 from Woods and Poole

	2004	2030	2030/ 2004
Total Employment (Thousands)	20,086	28,924	
Farm Employment	313	360	1.15
Agricultural Services, Other	407	607	1.49
Mining	32	41	1.28
Construction	1,041	1,476	1.42
Manufacturing	1,729	1,953	1.13
Transport, Comm. & Public Util	848	1,208	1.42
Wholesale Trade	907	1,198	1.32
Retail Trade	3,110	4,138	1.33
Finance, Ins. & Real Estate	1,844	2,539	1.38
Services	7,136	11,620	1.63
Federal Civilian Govt	249	245	0.98
Federal Military Govt	247	248	1.01
State and Local Govt	2,225	3,292	1.48
Total Earnings (Billions 1996 $)			
Farm Earnings	$7	$15	2.04
Agricultural Services, Other	$8	$15	1.87
Mining	$3	$4	1.28
Construction	$49	$81	1.64
Manufacturing	$123	$157	1.28
Transport, Comm. & Public Util	$48	$83	1.71
Wholesale Trade	$48	$72	1.50
Retail Trade	$73	$111	1.52
Finance, Ins. & Real Estate	$77	$146	1.90
Services	$281	$627	2.24
Federal Civilian Govt	$18	$21	1.19
Federal Military Govt	$11	$15	1.29
State And Local Govt	$105	$185	1.76
Gross Regional Prod. (Bill. 96 $)	$1,307	$2,346	

Table 30
California IMPLAN 2004 Output, and Predicted 2030 Output

Employee Compensation and Proprietor's Income in Billions of 2004 Dollars

Aggregated Sector Name	Billion $Output 2004	Billion $Output 2030	2004 Employment 1000s	2030 Employment	2030 Employee Compen-sation	2030 Proprietor Income
Crops	$29.3	$59.7	207	238	$9.6	$14.1
Livestock and Dairy	$18.9	$38.5	84	96	$3.3	$0.5
Other Ag For Fish	$9.9	$18.6	232	346	$9.1	$1.9
Oil and Gas	$10.9	$13.9	23	30	$1.9	$0.9
Mining	$2.5	$3.2	14	18	$1.1	$0.1
Construction	$209.1	$342.7	1,327	1,883	$96.0	$36.1
Manufacturing	$574.7	$733.5	1,561	1,762	$141.2	$7.5
Wholesale, transportation, storage	$196.0	$293.6	1,378	1,963	$106.4	$13.1
Retail	$150.4	$228.2	1,900	2,528	$81.5	$13.4
Publishing, communications, IT	$190.7	$289.3	544	723	$69.7	$13.1
Finance, Insurance, RE, rentals	$371.5	$705.0	1,851	2,549	$142.8	$51.9
Schools and Education	$17.8	$39.9	345	561	$21.6	$0.8
Medical and Social	$137.5	$307.6	1,636	2,665	$144.5	$25.3
Entertainment	$34.3	$76.7	497	809	$29.2	$6.2
Accommodations and Restaurants	$77.6	$173.6	1,408	2,293	$57.6	$4.0
Car, Repair and Pers. Services	$67.9	$151.9	713	1,161	$35.0	$14.5
Other Services	$319.7	$715.0	3,219	5,242	$322.6	$74.9
Religion & Civic	$15.0	$33.5	292	476	$20.6	$0.2
Other	$315.3	$554.6	2,825	4,179	$289.5	$0.0
TOTAL	$2,749.0	$4,778.9	20,057	29,524	$1,583.3	$278.7

3.0 Uncertainty in the Estimates

3.1 Types of Uncertainty

Uncertainty involves estimates or predictions that do not have a well-defined probability distribution. Uncertainty due to limited data and/or knowledge gaps is termed *epistemic* uncertainty. In principle, epistemic uncertainty can be reduced with the collection of more data. If enough data is collected then the probability distribution based on past events can be known with near certainty. This study contains a great deal of epistemic uncertainty. The economic activity in the Delta covers and extremely broad range of topics and issues. Given the time limits on this study, the economic analysis concentrated on those that appeared likely to involve the highest costs, and those for which we could rely on pre-existing analysis. As a result, many smaller topics were not investigated, or if investigated, were not able to be assigned cost estimates. As a result the cost estimates produced by this study will be biased low. The uncertainty resulting from this bias could be reduced by further data collection and analysis.

Aleatory uncertainty cannot be reduced even with the collection of more data. In economics, aleatory uncertainty often involves two types of phenomena 1) events that have little precedent in the past, so there is no data about them, and 2) future conditions that are known from past experience to be likely to change in unpredictable ways.

As an example in the economic consequences analysis, consider the analysis for natural gas production in the Delta. To develop this analysis, use was made of a distribution of natural gas prices in California, because prices for gas produced in the Delta was not readily available. There is some epistemic uncertainty that the price distribution we have is appropriate for the Delta, and this uncertainty could be reduced by collection of more data on Delta prices. However, the price distribution was based on past price experience, and it is possible, if not likely, that the pattern of gas prices will change in the future as demand grows. The uncertainty about the path of future gas prices is an aleatory uncertainty.

There is perhaps more uncertainty in economic results than in some other areas because economic phenomena are often the product of numerous uncertain factors. There may be a relatively small amount of uncertainty in the time required to rebuild and restore homes, and not much uncertainty in local home rental markets, but the real cost of lost use of homes is complicated by the uncertain behavior of residents, rental markets, insurers, and uncertain emergency response efforts. Katrina provides a possible data point that could be used to modify the simple analysis of lost residential use that we developed here. Rebuilding was limited by financial and institutional factors, and many New Orleans residents appear to have been permanently displaced. Some uncertainty in the cost estimates could be reduced by more data collection, but some of the institutional response variables cannot be determined, and could change in unpredictable ways according to national and state administration policies and decisions. For example, the amount of national funding available for use after a disaster may vary according to the state of the federal budget at that time, and other political concerns such as the perceived wealth of the state compared to that of the nation, or the perceived efficiency with which the state spends the money provided by the federal government. The power and influence of the state's congressional delegation at the time of the event could also influence the level of federal funding obtained. Even after a future levee failure event demonstrated the effect of those policies and administrative decisions for that event, there would still be considerable uncertainty as to whether the same policies and decisions would be adopted for future levee failures.

3.2 Assessment of Epistemic Uncertainty

There are many types of economic data whose uncertainty could be reduced by more data collection. In general, economic data are prices and quantities, and the economic analysis includes many physical results of flooding that change the prices and quantities. All three of these are subject to uncertainty. For example, cost of lost use of roads involves the average annual daily traffic (quantity) the cost per hour of travel (price) and the impact of lost use on the amount of travel, selection of alternate routes, and congestion (the physical result of the lost road). In economics, these three factors may affect each other. For example, the cost of travel may affect how much travel is foregone and the choice of alternate routes. Therefore, uncertainty in any of the three types of data inputs can result in uncertainty in the others. Uncertainty in travel costs leads to uncertainty in the amount and location of travel.

Areas of uncertainty where more data collection might help reduce uncertainty in the economic cost analysis include:

- Impacts of industrial water shortage on operations and loss of output
- Impacts of water shortage on local water markets and development of new, temporary supplies (water supply elasticity)
- More information regarding groundwater in SOD agricultural regions
- Market structure and elasticity of demand in home rental and business space markets.
- Information on the abilities and costs of continuing business operations following flood.
- Relationships between flood insurance, rebuilding and re-occupancy times.
- Impacts of flooding on natural gas production including well damages and losses.

3.3 Assessment of Aleatory Uncertainty

In economics, aleatory uncertainty occurs because there is a limited historical basis from which to estimate a distribution. In addition, because the structure of the economy and political decision making are changing over time, the applicability of historical experience to the outcome of future events may be limited. The amount of aleatory uncertainty generally increases with magnitude of an event because there is less likelihood of a relevant past experience, and because a variety of indirect, feedback and response mechanisms become more important. In some cases, multiple infrastructure failures might reinforce each other, and result in disproportionately costly results. In other cases (or the same cases under other conditions), multiple infrastructure failures might be offsetting, and so result in costs that are less than the sum of the costs of individual failures. For example, failure of water supply to San Joaquin farmers, failure of the Port of Stockton for fertilizer and transportation of product, and failure of the diesel transportation pipeline to Fresno could interact to provide multiple negative impacts to those farmers. Alternatively, the effect of the water supply shortage could be to reduce agricultural production such that the reductions in supplies of fertilizer, diesel and transportation would not have an effect on farmers. For unprecedented events such as a modern, major urban flood in California, there is no historical data, and each such future event could potentially exhibit sufficiently different responses that future outcomes would remain uncertain after historical data became available. However, some information may be gleaned from other disasters such as earthquakes, or from other places such as the gulf coast.

An important concern of any risk analysis investigating disaster scenarios is that the changes to the economy being investigated could be much larger than can readily be analyzed. Economic analyses typically take an existing economic structure as given, and introduce a perturbation (such as a factory closing or the introduction of a new industry or regulation) and follow the effects of that change onward through the economy. This study is investigating a range of potential occurrences that could significantly change the structure of the state's economy, even if only for a restricted period of time. While short term disruptions due to a limited number of levee breaches is unlikely to cause this concern, with a more widespread failure of Delta levees we are potentially dealing with a significant, if possibly short-term, disruption to the *structure* of the state's economy. The U.S. Bureau of Economic Analysis highlights the concern with the use of standard economic models for disaster analyses in the following caution:

> *(Input-Output models were) used to analyze the economic impacts of Hurricanes Andrew in 1992 and Charley in 2004, which, while devastating to those regions' residents, were not as catastrophic as Katrina. However,* **. . .** *(this) requires care, because natural disasters can cause substantial changes to the structure of the local economy.*
>
> *In the case of the New Orleans metropolitan area* **. . .** *dramatic alteration of the structure of a local economy makes using multipliers from regional input-output models* **. . .** *highly problematic. Regional multipliers reflect the industry linkages in a local economy at a given time, and so are best used to study less catastrophic events where those linkages are for the most part preserved.*[12]

A major basis for our analysis is that under some scenarios there is the potential that many essential linkages are at risk of being destroyed. For example, the possible loss of railways, gasoline and natural gas supplies could require the economy to change to more widespread use of trucking at a time when roads across the Delta might be compromised, fuel is more difficult and more expensive to purchase, or trucks already fully committed to a rebuilding effort. In some cases, the type of trucks required may be specialized, for example, fuel tankers or automobile carriers. For these reasons, the number and types of trucks needed may be unavailable or trucking may be very expensive following a

[12] Quoted from Bureau of Economic Analysis website http://www.bea.gov/bea/ARTICLES/REGIONAL/PERSINC/Meth/rims2.pdf.

widespread levee failure. This and the cost of increased congestion may make the consequences much higher than we anticipate.

Alternative management decisions could lead to a decrease in the production or imports of the goods shipped. The economic effects of either management decision will be very different, and will depend on a large number of variables not included in this analysis. Thus, like analyses of the effects of Katrina in New Orleans quoted above, this analysis runs the risk of using existing models outside the boundary conditions for which they were developed.

There are several categories of economic phenomena that cannot be predicted with much certainty:

- Response of prices and quantities in markets

The response of markets and resources to a major flood event is uncertain. Some prices may be regulated by emergency proclamation. The prices of important resources needed to rebuild may increase. Construction markets take time to adjust. After Katrina, costs of some important construction materials were affected. In addition, the ability of infrastructure to respond to disruptions is uncertain. For example, much of the analysis of infrastructure failure assumes that additional trucking services could reduce the costs of these failures. We have not addressed the extent to which such trucking services would be available, and whether the right type of trucks (tanker trucks, automobile transporters) would be available. The availability of these services could be expected to vary over time. So while the *epistemic* uncertainty of the current availability of trucking services could potentially be reduced by collection of more data, the *aleatory* uncertainty associated with future availability of such services cannot.

- Institutional response such as emergency aid and insurance

General categories are federal, State and local public services, and requirements for insurance payments. Recent press articles have contrasted the application of emergency aid in Florida and Louisiana after recent hurricanes, suggesting that historical experience cannot be used to determine future institutional responses.

- The behavior of affected persons

The unpredicted behavior of residents following Katrina were mentioned. As another example, businesses may attempt to rent elsewhere and continue, they may cease operations temporarily, or they may permanently relocate. There is no formula based on past precedent that could help.

- Technological, social and cultural change

For the 2030 condition, much aleatory uncertainty occurs because technological, social and cultural trends are hard to predict. Many attributes of today's economy would have been hard to predict 25 years ago. Our economic forecasts for 2030 are based generally on recent trends but without explicit technological changes.

In summary, the economic estimations for extensive levee failures under current conditions must be considered highly uncertain because of the lack of historical experience with similar failures. Economic estimations for future levee failures should be considered more uncertain, because the economy will change in ways that cannot be foreseen.

There are some additional factors that need to be remembered when examining the results of this analysis. The most important of these are discussed below:

1. Some of the scenarios investigated include the loss of levee integrity due to a major earthquake. In such an earthquake, some of the losses described here might occur both with and without levee failure. Because the study did not consider that some of the losses would occur in this manner, the study may include in its estimates the losses from earthquake failures that could not be avoided through levee repair. For example, the Mokelumne Aqueduct could be ruptured as a direct result of ground liquefaction from the earthquake, or as a result of levee failure that was caused by the earthquake. The analysis assumed that the aqueduct would continue to operate unless it was affected by scour resulting from levee failure. If the levee strength were increased so that it did not rupture during an earthquake, the aqueduct could still fail as a result of ground liquefaction. Thus repairing the levees would not provide protection to the aqueduct, but may lower the number of breaks that the aqueduct might sustain.
2. The distributional effects may be much larger than the economic costs. For example, a disruption of gasoline supplies crossing the Delta might lead to an increase in gasoline prices in the Central Valley and Nevada. Much of this would not be an economic cost, because it would reflect a transfer of income from Kinder Morgan (the pipeline company) and automobile drivers to alternative transportation (such as trucking firms) and those companies with fuel in storage to the east of the Delta. Thus Kinder Morgan and the average car driver might incur economic losses, but these could be at least partially offset by economic gains to tanker truck drivers. The net cost to the state as a whole would be much less than the cost to subparts of the state.

The additional economic costs from the price rise would result from any curtailment in economic activity that might occur as a result of the higher fuel costs, and are not readily measured. Taking this example to an extreme, it is possible that the net economic effect of a short term fuel shortage might be relatively small, but the political and social effects could be much greater.

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Appendix A
Lost Use of Residential and Business Structures and Public Services

Table A-1 shows population and housing data obtained or developed for the analysis. This consists of data from the 1990 Delta Atlas (DWR 1995), data developed by DWR from 2000 census data and DWR's projections to 2030 (Hambright 2007), and HAZUS data on number of residential structures are shown.

Results of the residential cost analysis by analysis zone for the 2005 condition are provided in Table A-2 for all zones except Suisun Marsh zones and unnamed zones, which are shown in Table A-3. Results are provided for the MHHW and the 100 year flood conditions. Reported estimates include the daily cost, the number of affected households, and the cost per event. Results are based on HAZUS estimates of residential housing units adjusted by an estimate of the share of units occupied (65%). Tables A-4 and A-5 provide the same results for the 2030 condition.

Table A-6 details the Impacts and Costs to California Businesses Caused by Lost Business Sales by Analysis Zone, per Day of Lost Use under 2005 Conditions, 100 Year Floodplain.

Table A-7 details the Impacts and Costs to California Businesses Caused by Lost Business Sales by Analysis Zone, per Day of Lost Use under 2030 Conditions, 100 Year Floodplain.

Table A-8 provides number of positions for some County and State offices. Table A-9 provides information on government offices and the lost use related to the associated public services.

Table A-1
Population and Household Data for Named Delta Islands and Place Names

Analysis Zone or Place Name	DWR 1990 Population	DWR 2000 Population	DWR 2000 Households	DWR 2030 Population	DWR 2030 Households	Estimate of All Residential Units, 100 yr Floodplan	Institutional Units, 100 Year Floodplain
Bacon_Island	260	180	0	180	0	0	5
Bethel_Island	2,115	2,312	1,345	3,337	1,885	1,158	0
Bishop_Tract	52	17	8	5,754	2,424	309	0
Bouldin_Island	74	0	0	0	0	0	0
Brack_Tract	80	21	5	21	5	13	0
Bradford_Island	0	48	40	48	40	38	0
Brannan-Andrus Island	2,093	1,837	1,015	2,829	1,408	632	0
Browns_Island						0	0
Byron_Tract (includes Discovery Bay)	6,336	6,211	2,747	7,818	3,337		
Byron_Tract 1						13	0
Byron_Tract 2						20	0
Byron_Tract 3						107	0
Canal Ranch	103	0	0	0	0	10	0
Chipps_Island						0	0
Clifton Court Forebay	16	27	15	27	15	2	0
Coney_Island	0	8	88	8	88	76	0
Deadhorse Island	39	4	2	4	2	1	0
Decker_Island	0	0	0	0	0	0	0
Discovery_Bay	see Byron Tract					2,802	0
Empire_Tract	5	38	11	54	18	9	0
Fabian_Tract	130	173	58	642	416	46	2
Fay Island		0	0	0	0	0	0
Glanville_Tract		60	18	74	22	21	1
Grand Island	1,021	1,174	503	1,355	571	415	1

Table A-1
Population and Household Data for Named Delta Islands and Place Names

Analysis Zone or Place Name	DWR 1990 Population	DWR 2000 Population	DWR 2000 Households	DWR 2030 Population	DWR 2030 Households	Estimate of All Residential Units, 100 yr Floodplan	Institutional Units, 100 Year Floodplain
Hastings_Tract	94	50	14	50	14		
Hastings_Tract 1						0	0
Hastings_Tract 2						12	0
Holland_Tract	35	27	18	27	18	16	0
Hotchkiss_Tract	847	968	489	1,583	802		
Hotchkiss_Tract 1						419	0
Hotchkiss_Tract 2						0	0
Jersey_Island	13	8	6	8	6	5	0
Jones_Tract	112	289	31	289	31	26	4
Upper Jones Tract	46						
Kimball Island	0	0	0	0	0	0	0
King_Island	195	237	107	338	222	90	1
Mandeville_Island	118	0	0	0	0	0	0
McCormack_Williamson_ Tract	0	0	0	0	0	0	0
McDonald_Tract	95	103	0	103	0	0	3
Medford_Island	14	23	1	23	1	0	1
Merritt Island	238	211	82	314	115	80	0
Moore Tract 1						6	0
Moore Tract 2						9	0
Moore Tract 3						19	0
Netherlands		1,027	344	1,181	384		
Netherlands 1						2	0
Netherlands 2						4	0
Netherlands 3						302	1
Netherlands 4						52	0

Table A-1
Population and Household Data for Named Delta Islands and Place Names

Analysis Zone or Place Name	DWR 1990 Population	DWR 2000 Population	DWR 2000 Households	DWR 2030 Population	DWR 2030 Households	Estimate of All Residential Units, 100 yr Floodplan	Institutional Units, 100 Year Floodplain
Netherlands 5						1	0
New_Hope_Tract	1,376	1,108	404	1,613	730	239	0
Palm-Orwood North	98	353	64	353	64	15	0
Palm-Orwood South	16					90	0
Paradise Junction						26	13
Pescadero						204	0
Peter Pocket						4	0
Pierson District	355	819	282	980	343		
Pierson District 1						190	0
Pierson District 2						4	0
Pierson District 3						51	0
Prospect_Island		2	2	2	2	2	0
Quimby_Island		0	1	0	1	1	0
RD 17 Mossdale						2,757	0
Rindge_Tract	33	44	13	132	46	8	0
Rio_Blanco_Tract	10	0	0	0	0	0	0
Roberts_Island	221	887	273	1,658	650		
Roberts_Island 1						198	6
Roberts_Island 2	435					2	0
Roberts_Island 3	231					0	0
Roberts_Island 4						52	0
Rough_and_Ready_Island	174	0	37	48	37	30	0
Ryer Island	246	287	98	333	114	68	0
Sargent_Barnhart_Tract	1,902	4,664	1,703	11,674	3,941		
Sargent_Barnhart_Tract 1						226	0
Sargent_Barnhart_Tract 2						4,297	0

Table A-1
Population and Household Data for Named Delta Islands and Place Names

Analysis Zone or Place Name	DWR 1990 Population	DWR 2000 Population	DWR 2000 Households	DWR 2030 Population	DWR 2030 Households	Estimate of All Residential Units, 100 yr Floodplan	Institutional Units, 100 Year Floodplain
Sargent_Barnhart_Tract 3						40	0
Sherman_Island	233	224	157	228	159	91	0
Shima_Tract	101	0	0	3,400	1,210	3,617	1
Shin_Kee_Tract	8	0	0	0	0	0	0
Staten_Island	35	40	11	50	16	10	0
Stewart_Tract	213	37	11	16,500	6,600	75	0
Sutter Island	173	121	48	121	48	40	0
Terminous_Tract	602	763	377	1,262	806		
Terminous_Tract 1						18	0
Terminous_Tract 2						270	0
Terminous_Tract 3						10	0
Twitchell_Island	87	115	79	130	88	58	0
Tyler_Island	644	540	222	676	276		
Tyler_Island 1						177	0
Tyler_Island 2						19	0
Union_Island	779	536	107	1,502	388		
Union_Island 1						100	4
Union_Island 2						0	0
Union_Island 3						2	0
Union_Island 4						2	0
Union_Island 5						0	0
Van_Sickle_Island						3	0
Veale_Tract	4	63	24	81	32		
Veale_Tract 1						3	0
Veale_Tract 2						43	0
Veale_Tract 3						2	1

Table A-1
Population and Household Data for Named Delta Islands and Place Names

Analysis Zone or Place Name	DWR 1990 Population	DWR 2000 Population	DWR 2000 Households	DWR 2030 Population	DWR 2030 Households	Estimate of All Residential Units, 100 yr Floodplan	Institutional Units, 100 Year Floodplain
Venice_Island	0	4	2	4	2	2	0
Victoria_Island	155	188	1	188	1	4	5
Walthal						173	0
Water Zone 1						461	1
Water Zone 2						1,125	1
Water Zone 3						172	0
Water Zone 4						233	0
Water Zone 5						240	1
Webb_Tract	0	2	1	2	1	1	0
West Sacramento North						7,738	8
W. Sacramento South 1						2,201	0
W. Sacramento South 2						0	0
Winter Island						0	0
Woodward_Island	6	0	0	0	0	0	0
Wright-Elmwood_Tract	31	2	1	2	1	4	0
Wright-Elmwood_Tract-Sargent Burnhart Tract						4,502	1
Totals 1.	22,299	25,852	10,865	67,006	27,380	36,610	61
Totals 2.	22,299	24,825	10,521	65,825	26,996	21,116	49

[1] Note that totals often do not include the same areas
[2] Totals are for comparable areas
Note that all zones are not likely to fail in a given scenario. The totals provide the total subject to risk, not the total expected to be affected by a Delta failure scenario.

Table A-2
Results of Residential Lost Use and Displacement Costs Analysis,
2005 Condition Named Delta Islands and Analysis Zones

	Mean Higher High Water Event				100 Year Event			
Analysis Zone	**Household Displace-ment Costs, $1000 per Day**	**Other Displace-ment Costs, $1000 per Day**	**Number of Occupied House-holds**	**Added Cost Per Event, $1000**	**Household Displace-ment Costs, $1000 per Day**	**Other Displace-ment Costs, $1000 per Day**	**Number of Occupied House-holds**	**Added Cost Per Event, $1000**
Bacon_Island	$0.0	$15.3	0	$0.0	$0.0	$15.3	0	$0.0
Bethel_Island	$28.7	$0.0	693	$346.7	$28.7	$0.0	693	$346.7
Bishop_Tract	$0.1	$0.0	3	$1.5	$7.6	$0.0	185	$92.4
Bouldin_Island	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Brack_Tract	$0.3	$0.0	7	$3.3	$0.3	$0.0	8	$3.9
Bradford_Island	$0.9	$0.0	22	$10.9	$0.9	$0.0	22	$10.9
Brannan-Andrus Island	$15.6	$0.0	365	$182.4	$15.6	$0.0	365	$182.4
Browns_Island	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Byron_Tract 1	$0.3	$0.0	7	$3.3	$0.3	$0.0	8	$3.9
Byron_Tract 2	$0.4	$0.0	11	$5.5	$0.5	$0.0	12	$6.1
Byron_Tract 3	$0.0	$0.0	0	$0.0	$2.7	$0.0	65	$32.4
Canal Ranch	$0.1	$0.0	2	$1.2	$0.2	$0.0	6	$3.0
Chipps_Island	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Clifton Court Forebay Water	$0.0	$0.0	1	$0.6	$0.0	$0.0	1	$0.6
Coney_Island	$1.9	$0.0	46	$23.0	$1.9	$0.0	46	$23.0
Deadhorse Island	$0.0	$0.0	1	$0.3	$0.0	$0.0	1	$0.3
Decker_Island	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Discovery_Bay	$0.0	$0.0	0	$0.0	$69.4	$0.0	1,697	$848.5
Empire_Tract	$0.2	$0.0	5	$2.7	$0.2	$0.0	5	$2.7
Fabian_Tract	$0.8	$5.1	16	$7.9	$1.1	$5.1	23	$11.5
Fay Island	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Glanville_Tract	$0.1	$0.0	2	$1.2	$0.5	$0.0	13	$6.4
Grand Island	$10.3	$3.9	245	$122.7	$10.3	$3.9	245	$122.7

Table A-2
Results of Residential Lost Use and Displacement Costs Analysis, 2005 Condition Named Delta Islands and Analysis Zones

	Mean Higher High Water Event				100 Year Event			
Analysis Zone	**Household Displace-ment Costs, $1000 per Day**	**Other Displace-ment Costs, $1000 per Day**	**Number of Occupied House-holds**	**Added Cost Per Event, $1000**	**Household Displace-ment Costs, $1000 per Day**	**Other Displace-ment Costs, $1000 per Day**	**Number of Occupied House-holds**	**Added Cost Per Event, $1000**
Hastings_Tract 1	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Hastings_Tract 2	$0.3	$0.0	7	$3.3	$0.3	$0.0	7	$3.6
Hotchkiss_Tract 1	$10.2	$0.0	239	$119.4	$10.4	$0.0	242	$121.2
Hotchkiss_Tract 2	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Jersey_Island	$0.1	$0.0	3	$1.5	$0.1	$0.0	3	$1.5
Jones_Tract	$0.6	$14.4	13	$6.7	$0.6	$14.4	13	$6.7
Kimball Island	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
King_Island	$2.2	$2.9	53	$26.7	$2.2	$2.9	53	$26.7
Liberte Island	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Little Holland Tract	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Mandeville_Island	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
McCormack_Williamson_Tract	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
McDonald_Tract	$0.0	$8.8	0	$0.0	$0.0	$8.8	0	$0.0
Medford_Island	$0.0	$1.6	0	$0.0	$0.0	$1.6	0	$0.0
Merritt Island	$1.0	$0.0	25	$12.7	$2.0	$0.0	48	$24.2
Moore Tract 1	$0.1	$0.0	4	$1.8	$0.1	$0.0	4	$1.8
Moore Tract 2	$0.0	$0.0	0	$0.0	$0.2	$0.0	5	$2.7
Moore Tract 3	$0.0	$0.0	1	$0.3	$0.5	$0.0	12	$5.8
Netherlands 1	$0.0	$0.0	0	$0.0	$0.0	$0.0	1	$0.6
Netherlands 2	$0.0	$0.0	0	$0.0	$0.1	$0.0	2	$1.2
Netherlands 3	$4.4	$0.0	107	$53.3	$7.5	$0.0	183	$91.5
Netherlands 4	$0.6	$0.0	13	$6.4	$1.3	$0.0	30	$15.2
Netherlands 5	$0.0	$0.0	0	$0.0	$0.0	$0.0	1	$0.3

Table A-2
Results of Residential Lost Use and Displacement Costs Analysis,
2005 Condition Named Delta Islands and Analysis Zones

	Mean Higher High Water Event				100 Year Event			
Analysis Zone	**Household Displace-ment Costs, $1000 per Day**	**Other Displace-ment Costs, $1000 per Day**	**Number of Occupied House-holds**	**Added Cost Per Event, $1000**	**Household Displace-ment Costs, $1000 per Day**	**Other Displace-ment Costs, $1000 per Day**	**Number of Occupied House-holds**	**Added Cost Per Event, $1000**
New_Hope_Tract	$2.6	$0.0	64	$32.1	$5.9	$0.0	144	$71.8
Palm-Orwood North	$0.4	$0.0	9	$4.5	$0.4	$0.0	9	$4.5
Palm-Orwood South	$2.1	$0.0	51	$25.5	$2.2	$0.0	55	$27.3
Paradise Junction	$0.0	$0.0	0	$0.0	$0.6	$0.0	16	$7.9
Pescadero	$0.0	$0.0	0	$0.0	$5.1	$0.0	124	$61.8
Peter Pocket	$0.0	$0.0	1	$0.3	$0.1	$0.0	2	$1.2
Pierson District 1	$3.7	$0.0	87	$43.3	$4.7	$0.0	110	$55.2
Pierson District 2	$0.0	$0.0	2	$1.2	$0.1	$0.0	2	$1.2
Pierson District 3	$1.3	$0.0	26	$13.0	$1.3	$0.0	26	$13.0
Prospect_Island	$0.0	$0.0	1	$0.6	$0.0	$0.0	1	$0.6
Quimby_Island	$0.0	$0.0	1	$0.3	$0.0	$0.0	1	$0.3
RD 17 Mossdale	$0.0	$0.0	0	$0.0	$68.3	$0.0	1,667	$833.6
Rindge_Tract	$0.2	$0.0	4	$1.8	$0.2	$0.0	4	$1.8
Rio_Blanco_Tract	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Roberts_Island 1	$4.7	$0.0	104	$52.1	$4.9	$0.0	110	$55.2
Roberts_Island 2	$0.0	$0.0	1	$0.6	$0.0	$0.0	1	$0.6
Roberts_Island 3	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Roberts_Island 4	$0.0	$0.0	1	$0.3	$1.3	$0.0	32	$15.8
Rough_and_Ready_Island	$0.7	$0.0	13	$6.4	$0.7	$0.0	15	$7.3
Ryer Island	$1.7	$0.0	41	$20.6	$1.7	$0.0	41	$20.6
Sargent_Barnhart_Tract 1	$0.0	$0.0	1	$0.3	$5.6	$0.0	104	$52.1
Sargent_Barnhart_Tract 2	$0.0	$0.0	14	$7.0	$106.5	$0.0	2,078	$1,039.1
Sargent_Barnhart_Tract 3	$0.0	$0.0	0	$0.0	$1.0	$0.0	18	$8.8

Table A-2
Results of Residential Lost Use and Displacement Costs Analysis, 2005 Condition Named Delta Islands and Analysis Zones

	Mean Higher High Water Event				100 Year Event			
Analysis Zone	**Household Displace-ment Costs, $1000 per Day**	**Other Displace-ment Costs, $1000 per Day**	**Number of Occupied House-holds**	**Added Cost Per Event, $1000**	**Household Displace-ment Costs, $1000 per Day**	**Other Displace-ment Costs, $1000 per Day**	**Number of Occupied House-holds**	**Added Cost Per Event, $1000**
Sherman_Island	$2.2	$0.0	52	$25.8	$2.2	$0.0	52	$25.8
Shima_Tract	$0.0	$0.0	0	$0.0	$89.6	$0.0	1,640	$820.0
Shin_Kee_Tract	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Staten_Island	$0.2	$0.0	6	$3.0	$0.2	$0.0	6	$3.0
Stewart_Tract	$0.0	$0.0	0	$0.0	$1.9	$0.0	45	$22.7
Sutter Island	$1.0	$0.0	24	$12.1	$1.0	$0.0	24	$12.1
Terminous_Tract 1	$0.1	$0.0	2	$0.9	$0.4	$0.0	11	$5.5
Terminous_Tract 2	$6.7	$0.0	161	$80.6	$6.7	$0.0	161	$80.6
Terminous_Tract 3	$0.2	$0.0	6	$3.0	$0.2	$0.0	6	$3.0
Twitchell_Island	$1.4	$0.0	32	$15.8	$1.4	$0.0	32	$15.8
Tyler_Island 1	$4.4	$0.0	90	$45.2	$4.4	$0.0	90	$45.2
Tyler_Island 2	$0.5	$0.0	12	$5.8	$0.5	$0.0	12	$5.8
Union_Island 1	$1.7	$0.0	38	$19.1	$2.5	$0.0	57	$28.5
Union_Island 2	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Union_Island 3	$0.0	$0.0	0	$0.0	$0.0	$0.0	1	$0.6
Union_Island 4	$0.0	$0.0	0	$0.0	$0.0	$0.0	1	$0.6
Union_Island 5	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Van_Sickle_Island	$0.1	$0.0	2	$0.9	$0.1	$0.0	2	$0.9
Veale_Tract 1	$0.0	$0.0	1	$0.6	$0.1	$0.0	2	$0.9
Veale_Tract 2	$0.9	$0.0	22	$10.9	$1.1	$0.0	26	$13.0
Veale_Tract 3	$0.0	$0.0	1	$0.6	$0.0	$0.0	1	$0.6
Venice_Island	$0.0	$0.0	1	$0.6	$0.0	$0.0	1	$0.6
Victoria_Island	$0.1	$15.4	2	$1.2	$0.1	$15.4	2	$1.2

Table A-2
Results of Residential Lost Use and Displacement Costs Analysis,
2005 Condition Named Delta Islands and Analysis Zones

	Mean Higher High Water Event				100 Year Event			
Analysis Zone	**Household Displace-ment Costs, $1000 per Day**	**Other Displace-ment Costs, $1000 per Day**	**Number of Occupied House-holds**	**Added Cost Per Event, $1000**	**Household Displace-ment Costs, $1000 per Day**	**Other Displace-ment Costs, $1000 per Day**	**Number of Occupied House-holds**	**Added Cost Per Event, $1000**
Walthal	$0.0	$0.0	0	$0.0	$4.3	$0.0	105	$52.4
Water Body	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Water Canal	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Water Zone 1	$4.7	$0.0	114	$57.0	$11.4	$0.0	270	$134.8
Water Zone 2	$6.4	$0.0	158	$78.8	$27.9	$0.0	677	$338.5
Water Zone 3	$2.4	$0.0	56	$27.9	$4.2	$0.0	101	$50.3
Water Zone 4	$1.6	$0.0	40	$20.0	$5.8	$0.0	122	$61.2
Water Zone 5	$0.0	$0.0	29	$14.5	$5.9	$0.0	145	$72.7
Webb_Tract	$0.0	$0.0	1	$0.3	$0.0	$0.0	1	$0.3
West Sacramento North	$0.0	$0.0	0	$0.0	$191.7	$0.0	3,921	$1,960.3
West Sacramento South 1	$0.0	$0.0	0	$0.0	$54.5	$0.0	1,327	$663.3
West Sacramento South 2	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Winter Island	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Woodward_Island	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Wright-Elmwood_Tract	$0.1	$0.0	2	$1.2	$0.1	$0.0	2	$1.2
Wright-Elmwood_Tract-Sargent Burnhart Tract	$40.7	$0.0	926	$463.0	$111.6	$0.0	2,232	$1,116.1
Totals	**$172.0**	**$67.4**	**4,090**	**$2,204.0**	**$905.0**	**$67.4**	**19,630**	**$9,817.6**

Note:
Totals do not reflect expected losses under specific levee failure conditions because all analysis zones are unlikely to be flooded in a single scenario.

Table A-3
Results of Residential Lost Use and Displacement Costs Analysis, 2005 Condition
Suisun Marsh and Other Analysis Zones

	Mean Higher High Water Event				100 Year Event			
Analysis Zone	Household Displacement Costs, $1000 per Day	Other Displacement Costs, $1000 per Day	Number of Occupied Households	Added Cost Per Event, $1000	Household Displacement Costs, $1000 per Day	Other Displacement Costs, $1000 per Day	Number of Occupied Households	Added Cost Per Event, $1000
SM-1	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
SM-123	$0.0	$0.0	1	$0.3	$0.4	$0.0	8	$3.9
SM-124	$0.0	$0.0	83	$41.5	$19.4	$0.0	358	$178.8
SM-131	$0.0	$0.0	1	$0.6	$0.0	$0.0	1	$0.6
SM-132	$0.0	$0.0	1	$0.3	$0.0	$0.0	1	$0.3
SM-133	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
SM-134	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
SM-198	$0.1	$0.0	2	$1.2	$0.1	$0.0	3	$1.5
SM-199	$0.0	$0.0	1	$0.6	$0.0	$0.0	1	$0.6
SM-2	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
SM-201	$0.0	$0.0	1	$0.3	$0.0	$0.0	1	$0.3
SM-202	$0.0	$0.0	1	$0.3	$0.0	$0.0	1	$0.3
SM-203	$0.0	$0.0	1	$0.3	$0.0	$0.0	1	$0.3
SM-204	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
SM-39	$0.0	$0.0	0	$0.0	$0.1	$0.0	4	$1.8
SM-40	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
SM-41	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
SM-42	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
SM-43	$0.0	$0.0	1	$0.3	$0.0	$0.0	1	$0.3
SM-44	$0.1	$0.0	2	$0.9	$0.2	$0.0	4	$2.1
SM-45	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0

Table A-3
Results of Residential Lost Use and Displacement Costs Analysis, 2005 Condition
Suisun Marsh and Other Analysis Zones

	Mean Higher High Water Event				100 Year Event			
Analysis Zone	Household Displacement Costs, $1000 per Day	Other Displacement Costs, $1000 per Day	Number of Occupied Households	Added Cost Per Event, $1000	Household Displacement Costs, $1000 per Day	Other Displacement Costs, $1000 per Day	Number of Occupied Households	Added Cost Per Event, $1000
SM-46	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
SM-47	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
SM-48	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
SM-49	$0.0	$0.0	1	$0.6	$0.2	$0.0	5	$2.7
SM-50	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
SM-51	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
SM-52	$0.0	$0.0	1	$0.6	$0.1	$0.0	2	$0.9
SM-53	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
SM-54	$0.0	$0.0	0	$0.0	$0.2	$0.0	5	$2.7
SM-55	$0.0	$0.0	1	$0.6	$0.0	$0.0	1	$0.6
SM-56	$0.1	$0.0	2	$0.9	$0.1	$0.0	2	$0.9
SM-57	$0.0	$0.0	0	$0.0	$0.5	$0.0	12	$5.8
SM-58	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
SM-59	$0.0	$0.0	1	$0.3	$0.0	$0.0	1	$0.3
SM-60	$0.0	$0.0	0	$0.0	$0.0	$0.0	1	$0.6
SM-84	$0.3	$0.0	7	$3.3	$0.3	$0.0	7	$3.3
SM-85	$0.1	$0.0	3	$1.5	$0.1	$0.0	3	$1.5
Zone 120	$0.0	$0.0	0	$0.0	$2.4	$0.0	58	$28.8
Zone 121	$0.0	$0.0	0	$0.0	$0.4	$0.0	10	$4.8
Zone 122	$0.0	$0.0	0	$0.0	$0.0	$0.0	1	$0.3
Zone 126	$1.3	$0.0	32	$15.8	$9.1	$0.0	221	$110.6
Zone 14	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0

Table A-3
Results of Residential Lost Use and Displacement Costs Analysis, 2005 Condition
Suisun Marsh and Other Analysis Zones

	Mean Higher High Water Event				100 Year Event			
Analysis Zone	Household Displacement Costs, $1000 per Day	Other Displacement Costs, $1000 per Day	Number of Occupied Households	Added Cost Per Event, $1000	Household Displacement Costs, $1000 per Day	Other Displacement Costs, $1000 per Day	Number of Occupied Households	Added Cost Per Event, $1000
Zone 148	$0.0	$0.0	0	$0.0	$0.9	$0.0	22	$10.9
Zone 155	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Zone 157	$0.0	$0.0	1	$0.3	$110.2	$0.0	2,489	$1,244.5
Zone 158	$0.0	$0.0	0	$0.0	$39.4	$0.0	799	$399.4
Zone 159	$0.0	$0.0	0	$0.0	$61.7	$0.0	1,464	$731.8
Zone 160	$0.0	$0.0	0	$0.0	$1.8	$0.0	43	$21.5
Zone 161	$0.0	$0.0	0	$0.0	$1.8	$0.0	43	$21.5
Zone 162	$0.1	$0.0	3	$1.5	$0.3	$0.0	7	$3.3
Zone 171	$0.0	$0.0	0	$0.0	$0.1	$0.0	3	$1.5
Zone 185	$0.0	$0.0	0	$0.0	$59.5	$0.0	1,358	$679.1
Zone 186	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Zone 196	$0.0	$0.0	0	$0.0	$2,014.2	$0.0	37,627	$18,813.6
Zone 197	$0.0	$0.0	0	$0.0	$1.8	$0.0	44	$22.1
Zone 206	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Zone 207	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Zone 209	$0.7	$0.0	18	$8.8	$3.0	$0.0	60	$30.0
Zone 214	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Zone 216	$0.0	$0.0	0	$0.0	$0.0	$0.0	1	$0.6
Zone 31	$0.0	$0.0	1	$0.6	$0.0	$0.0	1	$0.6
Zone 33	$0.0	$0.0	1	$0.3	$0.0	$0.0	1	$0.3
Zone 36	$0.0	$0.0	1	$0.3	$0.5	$0.0	13	$6.4
Zone 37	$0.2	$0.0	4	$2.1	$12.1	$0.0	218	$109.1

Table A-3
Results of Residential Lost Use and Displacement Costs Analysis, 2005 Condition
Suisun Marsh and Other Analysis Zones

	Mean Higher High Water Event				100 Year Event			
Analysis Zone	Household Displacement Costs, $1000 per Day	Other Displacement Costs, $1000 per Day	Number of Occupied Households	Added Cost Per Event, $1000	Household Displacement Costs, $1000 per Day	Other Displacement Costs, $1000 per Day	Number of Occupied Households	Added Cost Per Event, $1000
Zone 38	$0.0	$0.0	0	$0.0	$1.1	$0.0	21	$10.3
Zone 61	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Zone 64	$0.0	$0.0	1	$0.6	$0.5	$0.0	13	$6.7
Zone 65	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Zone 68	$0.1	$0.0	4	$1.8	$1.1	$0.0	25	$12.4
Zone 69	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Zone 70	$0.2	$0.0	5	$2.4	$0.3	$0.0	7	$3.6
Zone 74	$0.0	$0.0	0	$0.0	$1.1	$0.0	23	$11.5
Zone 75	$0.0	$0.0	0	$0.0	$1.3	$0.0	31	$15.5
Zone 76	$0.0	$0.0	0	$0.0	$88.3	$0.0	2,133	$1,066.4
Zone 77	$0.0	$0.0	0	$0.0	$0.5	$0.0	12	$5.8
Zone 78	$0.0	$0.0	0	$0.0	$1.0	$0.0	24	$12.1
Zone 79	$0.0	$0.0	0	$0.0	$0.1	$0.0	2	$0.9
Zone 80	$0.0	$0.0	0	$0.0	$0.0	$0.0	1	$0.6
Zone 81	$0.0	$0.0	0	$0.0	$0.2	$0.0	5	$2.7
Zone 82	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Zone 90	$0.0	$0.0	0	$0.0	$0.9	$0.0	23	$11.5
Total	$176.7	$67.3	4,276	$2,138.2	$3,344.9	$67.3	66,868	$33,433.9
Total Daily Cost		$244.0				$3,412.2		

Note:
Totals do not reflect expected losses under specific levee failure conditions because all analysis zones are unlikely to be flooded in a single scenario.

Table A-4
Results of Residential Lost Use and Displacement Costs Analysis, 2030 Conditions
Named Delta Islands and Analysis Zones

	Mean Higher High Water Event				100 Year Event			
Analysis Zone	**Household Displace-ment Costs, $1000 per Day**	**Other Displace -ment Costs, $1000 per Day**	**Number of Occupied House-holds**	**Added Cost Per Event, $1000**	**House-hold Displace-ment Costs, $1000 per Day**	**Other Pop. Dis-place-ment Costs, $1000 per Day**	**Number of Occupied Household s**	**Added Cost Per Event, $1000**
Bacon_Island	$0.0	$15.3	0	$0.0	$0.0	$15.3	0	$0.0
Bethel_Island	$40.2	$0.0	972	$485.8	$40.2	$0.0	972	$485.8
Bishop_Tract	$37.5	$0.0	918	$459.1	$2,316.2	$0.0	56,009	$28,004.5
Bouldin_Island	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Brack_Tract	$0.3	$0.0	7	$3.3	$0.3	$0.0	8	$3.9
Bradford_Island	$0.9	$0.0	22	$10.9	$0.9	$0.0	22	$10.9
Brannan-Andrus Island	$21.7	$0.0	506	$253.1	$21.7	$0.0	506	$253.1
Browns_Island	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Byron_Tract 1	$0.3	$0.0	8	$4.0	$0.4	$0.0	10	$4.8
Byron_Tract 2	$0.5	$0.0	13	$6.6	$0.6	$0.0	15	$7.4
Byron_Tract 3	$0.0	$0.0	0	$0.0	$3.2	$0.0	79	$39.4
Canal Ranch	$0.1	$0.0	2	$1.2	$0.2	$0.0	6	$3.0
Chipps_Island	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Clifton Court Forebay Water	$0.0	$0.0	1	$0.6	$0.0	$0.0	1	$0.6
Coney_Island	$1.9	$0.0	46	$23.0	$1.9	$0.0	46	$23.0
Deadhorse Island	$0.0	$0.0	1	$0.3	$0.0	$0.0	1	$0.3
Decker_Island	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Discovery_Bay	$0.0	$0.0	0	$0.0	$84.3	$0.0	2,061	$1,030.7
Empire_Tract	$0.4	$0.0	9	$4.5	$0.4	$0.0	9	$4.5

Table A-4
Results of Residential Lost Use and Displacement Costs Analysis, 2030 Conditions
Named Delta Islands and Analysis Zones

	Mean Higher High Water Event				100 Year Event			
Analysis Zone	Household Displace-ment Costs, $1000 per Day	Other Displace -ment Costs, $1000 per Day	Number of Occupied House-holds	Added Cost Per Event, $1000	House-hold Displace-ment Costs, $1000 per Day	Other Pop. Dis-place-ment Costs, $1000 per Day	Number of Occupied Household s	Added Cost Per Event, $1000
Fabian_Tract	$5.7	$18.9	113	$56.5	$8.2	$18.9	165	$82.6
Fay Island	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Glanville_Tract	$0.1	$0.0	3	$1.5	$0.6	$0.0	16	$7.8
Grand Island	$11.7	$4.5	279	$139.3	$11.7	$4.5	279	$139.3
Hastings_Tract 1	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Hastings_Tract 2	$0.3	$0.0	7	$3.3	$0.3	$0.0	7	$3.6
Holland_Tract	$0.4	$0.0	10	$4.8	$0.4	$0.0	10	$4.8
Hotchkiss_Tract	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Hotchkiss_Tract 1	$16.8	$0.0	392	$195.8	$17.0	$0.0	398	$198.8
Hotchkiss_Tract 2	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Jersey_Island	$0.1	$0.0	3	$1.5	$0.1	$0.0	3	$1.5
Jones_Tract	$0.6	$14.4	13	$6.7	$0.6	$14.4	13	$6.7
Kimball Island	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
King_Island	$4.6	$4.1	111	$55.3	$4.6	$4.1	111	$55.3
Liberte Island	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Little Holland Tract	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Mandeville_Island	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
McCormack_Williamson_Tract	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
McDonald_Tract	$0.0	$8.8	0	$0.0	$0.0	$8.8	0	$0.0
Medford_Island	$0.0	$1.6	0	$0.0	$0.0	$1.6	0	$0.0
Merritt Island	$1.5	$0.0	36	$17.8	$2.8	$0.0	68	$34.0

Table A-4
Results of Residential Lost Use and Displacement Costs Analysis, 2030 Conditions
Named Delta Islands and Analysis Zones

	Mean Higher High Water Event				100 Year Event			
Analysis Zone	Household Displace-ment Costs, $1000 per Day	Other Displace -ment Costs, $1000 per Day	Number of Occupied House-holds	Added Cost Per Event, $1000	House-hold Displace-ment Costs, $1000 per Day	Other Pop. Dis-place-ment Costs, $1000 per Day	Number of Occupied Household s	Added Cost Per Event, $1000
Moore Tract 1	$0.1	$0.0	4	$1.8	$0.1	$0.0	4	$1.8
Moore Tract 2	$0.0	$0.0	0	$0.0	$0.2	$0.0	5	$2.7
Moore Tract 3	$0.0	$0.0	1	$0.3	$0.5	$0.0	12	$5.8
Netherlands 1	$0.0	$0.0	0	$0.0	$0.1	$0.0	1	$0.7
Netherlands 2	$0.0	$0.0	0	$0.0	$0.1	$0.0	3	$1.3
Netherlands 3	$4.8	$0.0	116	$58.2	$8.2	$0.0	200	$99.8
Netherlands 4	$0.6	$0.0	14	$6.9	$1.4	$0.0	33	$16.5
Netherlands 5	$0.0	$0.0	0	$0.0	$0.0	$0.0	1	$0.3
New_Hope_Tract	$4.7	$0.0	116	$58.0	$10.7	$0.0	260	$129.8
Palm-Orwood North	$0.4	$0.0	9	$4.5	$0.4	$0.0	9	$4.5
Palm-Orwood South	$2.1	$0.0	51	$25.5	$2.2	$0.0	55	$27.3
Paradise Junction	$0.0	$0.0	0	$0.0	$0.9	$0.0	22	$11.0
Pescadero	$0.0	$0.0	0	$0.0	$7.1	$0.0	173	$86.4
Peter Pocket	$0.0	$0.0	1	$0.3	$0.1	$0.0	2	$1.2
Pierson District	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Pierson District 1	$4.5	$0.0	105	$52.7	$5.7	$0.0	134	$67.1
Pierson District 2	$0.0	$0.0	3	$1.5	$0.1	$0.0	3	$1.5
Pierson District 3	$1.5	$0.0	32	$15.8	$1.5	$0.0	32	$15.8
Prospect_Island	$0.0	$0.0	1	$0.6	$0.0	$0.0	1	$0.6
Quimby_Island	$0.0	$0.0	1	$0.3	$0.0	$0.0	1	$0.3
RD 17 Mossdale	$0.0	$0.0	0	$0.0	$95.5	$0.0	2,332	$1,165.8

Table A-4
Results of Residential Lost Use and Displacement Costs Analysis, 2030 Conditions
Named Delta Islands and Analysis Zones

	Mean Higher High Water Event				100 Year Event			
Analysis Zone	**Household Displace-ment Costs, $1000 per Day**	**Other Displace -ment Costs, $1000 per Day**	**Number of Occupied House-holds**	**Added Cost Per Event, $1000**	**House-hold Displace-ment Costs, $1000 per Day**	**Other Pop. Dis-place-ment Costs, $1000 per Day**	**Number of Occupied Household s**	**Added Cost Per Event, $1000**
Rindge_Tract	$0.7	$0.0	13	$6.4	$0.7	$0.0	13	$6.4
Rio_Blanco_Tract	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Roberts_Island 1	$11.1	$0.0	248	$124.1	$11.7	$0.0	263	$131.3
Roberts_Island 2	$0.1	$0.0	3	$1.4	$0.1	$0.0	3	$1.4
Roberts_Island 3	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Roberts_Island 4	$0.1	$0.0	1	$0.7	$3.1	$0.0	75	$37.5
Rough_&_Ready_Island	$0.7	$0.0	13	$6.4	$0.7	$0.0	15	$7.3
Ryer Island	$2.0	$0.0	48	$24.0	$2.0	$0.0	48	$24.0
Sargent_Barnhart_Tract 1	$0.0	$0.0	1	$0.7	$13.0	$0.0	241	$120.6
Sargent_Barnhart_Tract 2	$0.0	$0.0	32	$16.1	$246.4	$0.0	4,809	$2,404.6
Sargent_Barnhart_Tract 3	$0.0	$0.0	0	$0.0	$2.3	$0.0	41	$20.3
Sherman_Island	$2.3	$0.0	52	$26.1	$2.3	$0.0	52	$26.1
Shima_Tract	$0.0	$0.0	0	$0.0	$125.3	$0.0	2,293	$1,146.7
Shin_Kee_Tract	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Staten_Island	$0.4	$0.0	9	$4.4	$0.4	$0.0	9	$4.4
Stewart_Tract	$0.0	$0.0	0	$0.0	$1,115.1	$0.0	27,273	$13,636.4
Sutter Island	$1.0	$0.0	24	$12.1	$1.0	$0.0	24	$12.1
Terminous_Tract 1	$0.2	$0.0	4	$1.9	$1.0	$0.0	23	$11.7
Terminous_Tract 2	$14.3	$0.0	345	$172.3	$14.3	$0.0	345	$172.3
Terminous_Tract 3	$0.5	$0.0	13	$6.5	$0.5	$0.0	13	$6.5

Table A-4
Results of Residential Lost Use and Displacement Costs Analysis, 2030 Conditions
Named Delta Islands and Analysis Zones

	Mean Higher High Water Event				100 Year Event			
Analysis Zone	Household Displace-ment Costs, $1000 per Day	Other Displace -ment Costs, $1000 per Day	Number of Occupied House-holds	Added Cost Per Event, $1000	House-hold Displace-ment Costs, $1000 per Day	Other Pop. Dis-place-ment Costs, $1000 per Day	Number of Occupied Household s	Added Cost Per Event, $1000
Twitchell_Island	$1.6	$0.0	35	$17.6	$1.6	$0.0	35	$17.6
Tyler_Island 1	$5.5	$0.0	112	$56.1	$5.5	$0.0	112	$56.1
Tyler_Island 2	$0.6	$0.0	14	$7.2	$0.6	$0.0	14	$7.2
Union_Island 1	$6.2	$0.0	138	$69.2	$9.0	$0.0	207	$103.3
Union_Island 2	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Union_Island 3	$0.0	$0.0	0	$0.0	$0.2	$0.0	4	$2.2
Union_Island 4	$0.0	$0.0	0	$0.0	$0.2	$0.0	4	$2.2
Union_Island 5	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Van_Sickle_Island	$0.1	$0.0	2	$0.9	$0.1	$0.0	2	$0.9
Veale_Tract 1	$0.1	$0.0	2	$0.8	$0.1	$0.0	2	$1.2
Veale_Tract 2	$1.2	$0.0	29	$14.5	$1.4	$0.0	35	$17.4
Veale_Tract 3	$0.1	$0.0	2	$0.8	$0.1	$0.0	2	$0.8
Venice_Island	$0.0	$0.0	1	$0.6	$0.0	$0.0	1	$0.6
Victoria_Island	$0.1	$15.4	2	$1.2	$0.1	$15.4	2	$1.2
Walthal	$0.0	$0.0	0	$0.0	$6.0	$0.0	147	$73.3
Water Body	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Water Canal	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Water Zone 1	$6.5	$0.0	159	$79.7	$16.0	$0.0	377	$188.6
Water Zone 2	$9.0	$0.0	220	$110.2	$39.0	$0.0	947	$473.3
Water Zone 3	$3.4	$0.0	78	$39.0	$5.9	$0.0	141	$70.3
Water Zone 4	$2.3	$0.0	56	$28.0	$8.1	$0.0	171	$85.6

Table A-4
Results of Residential Lost Use and Displacement Costs Analysis, 2030 Conditions
Named Delta Islands and Analysis Zones

	Mean Higher High Water Event				100 Year Event			
Analysis Zone	**Household Displace-ment Costs, $1000 per Day**	**Other Displace -ment Costs, $1000 per Day**	**Number of Occupied House-holds**	**Added Cost Per Event, $1000**	**House-hold Displace-ment Costs, $1000 per Day**	**Other Pop. Dis-place-ment Costs, $1000 per Day**	**Number of Occupied Household s**	**Added Cost Per Event, $1000**
Water Zone 5	$0.0	$0.0	41	$20.3	$8.3	$0.0	203	$101.7
Webb_Tract	$0.0	$0.0	1	$0.3	$0.0	$0.0	1	$0.3
West Sacramento North	$0.0	$0.0	0	$0.0	$276.8	$0.0	5,661	$2,830.4
West Sacramento South 1	$0.0	$0.0	0	$0.0	$78.7	$0.0	1,916	$957.8
West Sacramento South 2	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Winter Island	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Woodward_Island	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Wright-Elmwood_Tract	$0.1	$0.0	2	$1.2	$0.1	$0.0	2	$1.2
Wright-Elmwood_Tract-Sargent Burnhart Tract	$56.9	$0.0	1,295	$647.5	$156.0	$0.0	3,121	$1,560.7

Table A-5
Results of Residential Lost Use and Displacement Costs Analysis, 2030 Conditions
Suisun Marsh and Other Analysis Zones

	Mean Higher High Water Event				100 Year Event			
Analysis Zone	Household Displace-ment Costs, $1000 per Day	Other Displace-ment Costs, $1000 per Day	Number of Occupied House-holds	Added Cost Per Event, $1000	Household Displace-ment Costs, $1000 per Day	Other Displace-ment Costs, $1000 per Day	Number of Occupied House-holds	Added Cost Per Event, $1000
SM-1	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
SM-123	$0.0	$0.0	1	$0.5	$0.7	$0.0	13	$6.4
SM-124	$0.0	$0.0	135	$67.7	$31.6	$0.0	583	$291.7
SM-131	$0.1	$0.0	2	$1.0	$0.1	$0.0	2	$1.0
SM-132	$0.0	$0.0	1	$0.5	$0.0	$0.0	1	$0.5
SM-133	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
SM-134	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
SM-198	$0.2	$0.0	4	$2.0	$0.2	$0.0	5	$2.5
SM-199	$0.1	$0.0	2	$1.0	$0.1	$0.0	2	$1.0
SM-2	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
SM-201	$0.0	$0.0	1	$0.5	$0.0	$0.0	1	$0.5
SM-202	$0.0	$0.0	1	$0.5	$0.0	$0.0	1	$0.5
SM-203	$0.0	$0.0	1	$0.5	$0.0	$0.0	1	$0.5
SM-204	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
SM-39	$0.0	$0.0	0	$0.0	$0.2	$0.0	6	$3.0
SM-40	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
SM-41	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
SM-42	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
SM-43	$0.0	$0.0	1	$0.5	$0.0	$0.0	1	$0.5
SM-44	$0.1	$0.0	3	$1.5	$0.3	$0.0	7	$3.5
SM-45	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
SM-46	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0

Table A-5
Results of Residential Lost Use and Displacement Costs Analysis, 2030 Conditions
Suisun Marsh and Other Analysis Zones

	Mean Higher High Water Event				100 Year Event			
Analysis Zone	Household Displace-ment Costs, $1000 per Day	Other Displace-ment Costs, $1000 per Day	Number of Occupied House-holds	Added Cost Per Event, $1000	Household Displace-ment Costs, $1000 per Day	Other Displace-ment Costs, $1000 per Day	Number of Occupied House-holds	Added Cost Per Event, $1000
SM-47	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
SM-48	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
SM-49	$0.1	$0.0	2	$1.0	$0.4	$0.0	9	$4.4
SM-50	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
SM-51	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
SM-52	$0.1	$0.0	2	$1.0	$0.1	$0.0	3	$1.5
SM-53	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
SM-54	$0.0	$0.0	0	$0.0	$0.4	$0.0	9	$4.4
SM-55	$0.1	$0.0	2	$1.0	$0.1	$0.0	2	$1.0
SM-56	$0.1	$0.0	3	$1.5	$0.1	$0.0	3	$1.5
SM-57	$0.0	$0.0	0	$0.0	$0.8	$0.0	19	$9.4
SM-58	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
SM-59	$0.0	$0.0	1	$0.5	$0.0	$0.0	1	$0.5
SM-60	$0.0	$0.0	0	$0.0	$0.1	$0.0	2	$1.0
SM-84	$0.4	$0.0	11	$5.4	$0.4	$0.0	11	$5.4
SM-85	$0.2	$0.0	5	$2.5	$0.2	$0.0	5	$2.5
Zone 120	$0.0	$0.0	0	$0.0	$3.3	$0.0	81	$40.3
Zone 121	$0.0	$0.0	0	$0.0	$0.6	$0.0	14	$6.8
Zone 122	$0.0	$0.0	0	$0.0	$0.0	$0.0	1	$0.4
Zone 126	$1.8	$0.0	44	$22.0	$12.8	$0.0	309	$154.7
Zone 14	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Zone 148	$0.0	$0.0	0	$0.0	$1.3	$0.0	33	$16.3

Table A-5
Results of Residential Lost Use and Displacement Costs Analysis, 2030 Conditions
Suisun Marsh and Other Analysis Zones

	Mean Higher High Water Event				100 Year Event			
Analysis Zone	Household Displace-ment Costs, $1000 per Day	Other Displace-ment Costs, $1000 per Day	Number of Occupied House-holds	Added Cost Per Event, $1000	Household Displace-ment Costs, $1000 per Day	Other Displace-ment Costs, $1000 per Day	Number of Occupied House-holds	Added Cost Per Event, $1000
Zone 155	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Zone 157	$0.0	$0.0	1	$0.4	$154.1	$0.0	3,481	$1,740.4
Zone 158	$0.0	$0.0	0	$0.0	$55.1	$0.0	1,117	$558.5
Zone 159	$0.0	$0.0	0	$0.0	$86.2	$0.0	2,047	$1,023.4
Zone 160	$0.0	$0.0	0	$0.0	$2.5	$0.0	60	$30.1
Zone 161	$0.0	$0.0	0	$0.0	$2.5	$0.0	60	$30.1
Zone 162	$0.2	$0.0	4	$2.1	$0.4	$0.0	9	$4.7
Zone 171	$0.0	$0.0	0	$0.0	$0.2	$0.0	4	$2.1
Zone 185	$0.0	$0.0	0	$0.0	$83.2	$0.0	1,899	$949.7
Zone 186	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Zone 196	$0.0	$0.0	0	$0.0	$3,001.6	$0.0	56,072	$28,036.2
Zone 197	$0.0	$0.0	0	$0.0	$2.7	$0.0	66	$33.0
Zone 206	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Zone 207	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Zone 209	$1.1	$0.0	26	$13.1	$4.5	$0.0	90	$44.8
Zone 214	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Zone 216	$0.0	$0.0	0	$0.0	$0.1	$0.0	2	$0.8
Zone 31	$0.0	$0.0	2	$0.8	$0.1	$0.0	2	$0.8
Zone 33	$0.0	$0.0	1	$0.4	$0.0	$0.0	1	$0.4
Zone 36	$0.0	$0.0	1	$0.5	$0.8	$0.0	21	$10.4
Zone 37	$0.3	$0.0	7	$3.5	$19.7	$0.0	356	$178.0
Zone 38	$0.0	$0.0	0	$0.0	$1.7	$0.0	31	$15.4

Table A-5
Results of Residential Lost Use and Displacement Costs Analysis, 2030 Conditions
Suisun Marsh and Other Analysis Zones

	Mean Higher High Water Event				100 Year Event			
Analysis Zone	**Household Displace-ment Costs, $1000 per Day**	**Other Displace-ment Costs, $1000 per Day**	**Number of Occupied House-holds**	**Added Cost Per Event, $1000**	**Household Displace-ment Costs, $1000 per Day**	**Other Displace-ment Costs, $1000 per Day**	**Number of Occupied House-holds**	**Added Cost Per Event, $1000**
Zone 61	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Zone 64	$0.0	$0.0	2	$1.0	$0.9	$0.0	22	$10.9
Zone 65	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Zone 68	$0.2	$0.0	6	$3.0	$1.7	$0.0	41	$20.3
Zone 69	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Zone 70	$0.3	$0.0	8	$4.0	$0.5	$0.0	12	$5.9
Zone 74	$0.0	$0.0	0	$0.0	$1.6	$0.0	33	$16.6
Zone 75	$0.0	$0.0	0	$0.0	$1.9	$0.0	46	$23.0
Zone 76	$0.0	$0.0	0	$0.0	$131.6	$0.0	3,178	$1,589.1
Zone 77	$0.0	$0.0	0	$0.0	$0.7	$0.0	17	$8.6
Zone 78	$0.0	$0.0	0	$0.0	$1.5	$0.0	36	$18.1
Zone 79	$0.0	$0.0	0	$0.0	$0.1	$0.0	3	$1.5
Zone 80	$0.0	$0.0	0	$0.0	$0.1	$0.0	2	$1.0
Zone 81	$0.0	$0.0	0	$0.0	$0.4	$0.0	9	$4.4
Zone 82	$0.0	$0.0	0	$0.0	$0.0	$0.0	0	$0.0
Zone 90	$0.0	$0.0	0	$0.0	$1.4	$0.0	34	$17.2
Total	$297.1	$83.0	7,200	$3,599.9	$8,416.9	$83.0	182,615	$91,307.3
Total Daily Cost		$380.1				$8,499.8		

Note:
Totals do not reflect expected losses under specific levee failure conditions because all analysis zones are unlikely to be flooded in a single scenario.

Table A-6
Impacts and Costs to California Businesses Caused by Lost Business Sales by Analysis Zone, per Day of Lost Use 2005 Conditions, 100-Year Floodplain

Analysis Zones	Number of Businesses	1000 $ Value of Output	Years Employ-ment	1000 $ Labor income	1000 $ Value added 1.	1000 $ Lost Profit	1000 $ One-time cost if flooded
Bacon_Island	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Bethel_Island	110	$57.7	0.33	$18.8	$32.8	$2.9	$110.0
Bishop_Tract	17	$7.8	0.02	$2.3	$4.6	$0.4	$17.0
Bouldin_Island	14	$30.8	0.64	$10.2	$16.8	$1.5	$14.0
Brack_Tract	1	$0.0	0.00	$0.0	$0.0	$0.0	$1.0
Bradford_Island	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Brannan-Andrus Island	148	$77.5	1.29	$27.6	$44.0	$3.9	$148.0
Browns_Island	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Byron_Tract 1	58	$32.9	0.27	$10.8	$19.0	$1.6	$58.0
Byron_Tract 2	1	$0.0	0.00	$0.0	$0.0	$0.0	$1.0
Byron_Tract 3	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Canal Ranch	3	$0.2	0.00	$0.1	$0.1	$0.0	$3.0
Chipps_Island	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Clifton Court Forebay Water	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Coney_Island	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Deadhorse Island	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Decker_Island	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Discovery_Bay	136	$86.4	0.89	$26.2	$51.4	$4.3	$136.0
Empire_Tract	3	$6.7	0.13	$3.6	$5.0	$0.3	$3.0
Fabian_Tract	9	$3.4	0.06	$1.2	$1.8	$0.2	$9.0
Fay Island	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Glanville_Tract	1	$0.0	0.00	$0.0	$0.0	$0.0	$1.0
Grand Island	43	$27.7	0.29	$9.4	$16.2	$1.4	$43.0
Hastings_Tract 1	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Hastings_Tract 2	1	$0.0	0.04	$0.0	$0.0	$0.0	$1.0

Table A-6
Impacts and Costs to California Businesses Caused by Lost Business Sales by Analysis Zone, per Day of Lost Use 2005 Conditions, 100-Year Floodplain

Analysis Zones	Number of Businesses	1000 $ Value of Output	Years Employ-ment	1000 $ Labor income	1000 $ Value added 1.	1000 $ Lost Profit	1000 $ One-time cost if flooded
Holland_Tract	1	$0.5	0.00	$0.2	$0.3	$0.0	$1.0
Hotchkiss_Tract 1	26	$8.9	0.03	$2.9	$4.8	$0.4	$26.0
Hotchkiss_Tract 2	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Jersey_Island	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Jones_Tract	1	$0.0	0.01	$0.0	$0.0	$0.0	$1.0
Kimball Island	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
King_Island	9	$1.8	0.38	$0.6	$1.2	$0.1	$9.0
Liberte Island	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Little Holland Tract	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Mandeville_Island	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
McCormack_Williamson_Tract	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
McDonald_Tract	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Medford_Island	1	$0.0	0.01	$0.0	$0.0	$0.0	$1.0
Merritt Island	2	$0.0	0.07	$0.0	$0.0	$0.0	$2.0
Moore Tract 1	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Moore Tract 2	2	$0.1	0.01	$0.0	$0.1	$0.0	$2.0
Moore Tract 3	1	$0.3	0.00	$0.2	$0.2	$0.0	$1.0
Netherlands 1	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Netherlands 2	1	$1.1	0.03	$0.4	$0.6	$0.1	$1.0
Netherlands 3	46	$34.6	0.14	$9.1	$15.0	$1.7	$46.0
Netherlands 4	6	$0.7	0.06	$0.3	$0.4	$0.0	$6.0
Netherlands 5	1	$0.5	0.00	$0.2	$0.3	$0.0	$1.0
New_Hope_Tract	6	$2.5	0.01	$0.9	$1.5	$0.1	$6.0
Palm-Orwood North	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Palm-Orwood South	2	$0.3	0.86	$0.1	$0.2	$0.0	$2.0
Paradise Junction	2	$1.6	1.43	$0.6	$0.9	$0.1	$2.0

Table A-6
Impacts and Costs to California Businesses Caused by Lost Business Sales by Analysis Zone, per Day of Lost Use 2005 Conditions, 100-Year Floodplain

Analysis Zones	Number of Businesses	1000 $ Value of Output	Years Employ-ment	1000 $ Labor income	1000 $ Value added 1.	1000 $ Lost Profit	1000 $ One-time cost if flooded
Pescadero	20	$21.6	0.12	$5.0	$8.2	$1.1	$20.0
Peter Pocket	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Pierson District 1	47	$15.8	0.29	$4.3	$7.7	$0.8	$47.0
Pierson District 2	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Pierson District 3	11	$1.1	0.02	$0.4	$0.6	$0.1	$11.0
Prospect_Island	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Quimby_Island	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
RD 17 Mossdale	162	$1,186.6	5.56	$259.6	$428.4	$59.3	$162.0
Rindge_Tract	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Rio_Blanco_Tract	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Roberts_Island 1	37	$56.7	0.58	$12.3	$21.6	$2.8	$37.0
Roberts_Island 2	1	$0.5	0.00	$0.2	$0.3	$0.0	$1.0
Roberts_Island 3	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Roberts_Island 4	2	$0.0	0.00	$0.0	$0.0	$0.0	$2.0
Rough_and_Ready_Island	34	$373.8	4.07	$115.8	$179.7	$18.7	$34.0
Ryer Island	5	$0.3	0.12	$0.1	$0.2	$0.0	$5.0
Sargent_Barnhart_Tract 1	5	$2.0	0.01	$0.7	$1.3	$0.1	$5.0
Sargent_Barnhart_Tract 2	120	$92.4	0.80	$32.8	$54.1	$4.6	$120.0
Sargent_Barnhart_Tract 3	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Sherman_Island	3	$3.2	0.03	$1.6	$1.8	$0.2	$3.0
Shima_Tract	195	$101.8	0.79	$36.9	$62.3	$5.1	$195.0
Shin_Kee_Tract	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
SM-1	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
SM-123	2	$7.3	0.07	$2.1	$3.2	$0.4	$2.0
SM-124	178	$72.2	0.77	$23.9	$43.4	$3.6	$178.0
SM-131	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0

Table A-6
Impacts and Costs to California Businesses Caused by Lost Business Sales by Analysis Zone, per Day of Lost Use 2005 Conditions, 100-Year Floodplain

Analysis Zones	Number of Businesses	1000 $ Value of Output	Years Employ-ment	1000 $ Labor income	1000 $ Value added 1.	1000 $ Lost Profit	1000 $ One-time cost if flooded
SM-132	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
SM-133	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
SM-134	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
SM-198	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
SM-199	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
SM-2	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
SM-201	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
SM-202	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
SM-203	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
SM-204	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
SM-39	7	$17.1	0.22	$4.8	$9.7	$0.9	$7.0
SM-40	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
SM-41	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
SM-42	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
SM-43	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
SM-44	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
SM-45	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
SM-46	1	$0.0	0.00	$0.0	$0.0	$0.0	$1.0
SM-47	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
SM-48	2	$0.0	0.01	$0.0	$0.0	$0.0	$2.0
SM-49	11	$14.1	0.09	$4.3	$7.3	$0.7	$11.0
SM-50	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
SM-51	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
SM-52	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
SM-53	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
SM-54	74	$629.0	4.22	$198.4	$315.5	$31.4	$74.0

Table A-6
Impacts and Costs to California Businesses Caused by Lost Business Sales by Analysis Zone, per Day of Lost Use 2005 Conditions, 100-Year Floodplain

Analysis Zones	Number of Businesses	1000 $ Value of Output	Years Employ-ment	1000 $ Labor income	1000 $ Value added 1.	1000 $ Lost Profit	1000 $ One-time cost if flooded
SM-55	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
SM-56	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
SM-57	73	$40.2	0.14	$13.3	$23.1	$2.0	$73.0
SM-58	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
SM-59	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
SM-60	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
SM-84	3	$0.0	0.00	$0.0	$0.0	$0.0	$3.0
SM-85	2	$0.0	0.00	$0.0	$0.0	$0.0	$2.0
Staten_Island	3	$6.4	0.06	$1.5	$2.4	$0.3	$3.0
Stewart_Tract	7	$5.9	0.04	$2.0	$3.1	$0.3	$7.0
Sutter Island	4	$0.2	0.01	$0.1	$0.1	$0.0	$4.0
Terminous_Tract 1	6	$1.4	0.02	$0.5	$0.8	$0.1	$6.0
Terminous_Tract 2	4	$0.9	0.00	$0.4	$0.5	$0.0	$4.0
Terminous_Tract 3	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Twitchell_Island	1	$0.4	0.00	$0.1	$0.3	$0.0	$1.0
Tyler_Island 1	37	$6.9	0.09	$2.8	$4.1	$0.3	$37.0
Tyler_Island 2	11	$67.2	0.22	$9.8	$18.1	$3.4	$11.0
Union_Island 1	13	$15.0	0.22	$6.7	$8.7	$0.7	$13.0
Union_Island 2	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Union_Island 3	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Union_Island 4	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Union_Island 5	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Van_Sickle_Island	13	$15.0	0.22	$6.7	$8.7	$0.7	$13.0
Veale_Tract 1	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Veale_Tract 2	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Veale_Tract 3	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0

Table A-6
Impacts and Costs to California Businesses Caused by Lost Business Sales by Analysis Zone, per Day of Lost Use 2005 Conditions, 100-Year Floodplain

Analysis Zones	Number of Businesses	1000 $ Value of Output	Years Employ-ment	1000 $ Labor income	1000 $ Value added 1.	1000 $ Lost Profit	1000 $ One-time cost if flooded
Venice_Island	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Victoria_Island	1	$0.0	0.00	$0.0	$0.0	$0.0	$1.0
Walthal	5	$12.9	0.14	$3.8	$7.4	$0.6	$5.0
Water Body	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Water Canal	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Water Zone 1	63	$42.1	0.48	$16.3	$23.2	$2.1	$63.0
Water Zone 2	18	$33.1	0.22	$5.1	$8.7	$1.7	$18.0
Water Zone 3	21	$9.9	0.09	$3.2	$5.7	$0.5	$21.0
Water Zone 4	28	$26.3	0.21	$10.7	$15.9	$1.3	$28.0
Water Zone 5	28	$26.3	0.21	$10.7	$15.9	$1.3	$28.0
Webb_Tract	28	$26.3	0.21	$10.7	$15.9	$1.3	$28.0
West Sacramento North	1368	$2,597.8	22.76	$865.6	$1,359.2	$129.9	$1,368.0
West Sacramento South 1	105	$98.7	0.80	$29.2	$58.3	$4.9	$105.0
West Sacramento South 2	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Winter Island	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Woodward_Island	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Wright-Elmwood_Tract	2	$0.0	0.20	$0.0	$0.0	$0.0	$2.0
Wright-Elmwood_Tract-Sargent Burnhart Tract	652	$1,208.1	10.22	$444.3	$720.5	$60.4	$652.0
Zone 120	5	$0.5	0.04	$0.2	$0.3	$0.0	$5.0
Zone 121	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Zone 122	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Zone 126	290	$348.7	2.02	$109.9	$176.7	$17.4	$290.0
Zone 14	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Zone 148	1	$0.0	0.00	$0.0	$0.0	$0.0	$1.0
Zone 155	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Zone 157	167	$54.9	0.79	$18.7	$33.4	$2.7	$167.0

Table A-6
Impacts and Costs to California Businesses Caused by Lost Business Sales by Analysis Zone, per Day of Lost Use 2005 Conditions, 100-Year Floodplain

Analysis Zones	Number of Businesses	1000 $ Value of Output	Years Employ-ment	1000 $ Labor income	1000 $ Value added 1.	1000 $ Lost Profit	1000 $ One-time cost if flooded
Zone 158	104	$416.6	1.77	$126.0	$204.7	$20.8	$104.0
Zone 159	157	$793.9	5.13	$215.7	$352.0	$39.7	$157.0
Zone 160	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Zone 161	3	$0.2	0.01	$0.1	$0.1	$0.0	$3.0
Zone 162	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Zone 171	1	$1.6	0.02	$0.9	$0.9	$0.1	$1.0
Zone 185	32	$51.7	0.66	$23.1	$30.9	$2.6	$32.0
Zone 186	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Zone 196	10741	$14,568.8	143.83	$5,395.6	$8,219.7	$728.4	$10,741.0
Zone 197	15	$3.5	0.03	$1.2	$2.1	$0.2	$15.0
Zone 206	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Zone 207	15	$3.5	0.03	$1.2	$2.1	$0.2	$15.0
Zone 209	18	$168.0	1.55	$45.3	$95.8	$8.4	$18.0
Zone 214	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Zone 216	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Zone 31	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Zone 33	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Zone 36	3	$0.5	0.00	$0.3	$0.3	$0.0	$3.0
Zone 37	75	$71.3	0.57	$25.7	$36.9	$3.6	$75.0
Zone 38	25	$18.3	0.18	$7.3	$10.7	$0.9	$25.0
Zone 61	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Zone 64	14	$0.0	0.00	$0.0	$0.0	$0.0	$14.0
Zone 65	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Zone 68	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Zone 69	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Zone 70	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0

Table A-6
Impacts and Costs to California Businesses Caused by Lost Business Sales by Analysis Zone, per Day of Lost Use 2005 Conditions, 100-Year Floodplain

Analysis Zones	Number of Businesses	1000 $ Value of Output	Years Employ-ment	1000 $ Labor income	1000 $ Value added 1.	1000 $ Lost Profit	1000 $ One-time cost if flooded
Zone 74	1	$0.0	0.00	$0.0	$0.0	$0.0	$1.0
Zone 75	4	$0.9	0.01	$0.4	$0.6	$0.0	$4.0
Zone 76	169	$641.0	3.76	$158.3	$232.8	$32.1	$169.0
Zone 77	18	$6.1	0.10	$2.0	$3.4	$0.3	$18.0
Zone 78	1	$0.0	0.00	$0.0	$0.0	$0.0	$1.0
Zone 79	1	$0.0	0.00	$0.0	$0.0	$0.0	$1.0
Zone 80	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Zone 81	2	$18.9	0.16	$5.5	$8.3	$0.9	$2.0
Zone 82	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Zone 90	3	$6.3	0.19	$1.5	$3.4	$0.3	$3.0
TOTAL	15,930	$24,396.1	222.18	$8,411.2	$13,078.6	$1,219.8	$15,930.0

Note:
Totals do not reflect expected losses under specific levee failure conditions because all analysis zones are unlikely to be flooded in a single scenario

Table A-7
Impacts and Costs to California Businesses Caused by Lost Business Sales by Analysis Zone, per Day of Lost Use 2030 Conditions, 100-Year Floodplain

Analysis Zones	Number of businesses	1000 $ Value of Output	Years Employ-ment	1000 $ Labor income	1000 $ Value added 1.	1000 $ Lost Profit	1000 $ One-time cost if flooded
Bacon_Island	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Bethel_Island	110	$111.5	0.54	$37.0	$65.1	$5.6	$110.0
Bishop_Tract	17	$11.3	0.03	$3.6	$6.8	$0.6	$17.0
Bouldin_Island	14	$56.4	0.93	$19.0	$30.9	$2.8	$14.0
Brack_Tract	1	$0.0	0.00	$0.0	$0.0	$0.0	$1.0
Bradford_Island	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Brannan-Andrus Island	148	$169.5	1.61	$62.3	$97.6	$8.5	$148.0
Browns_Island	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Byron_Tract 1	58	$66.2	0.44	$22.5	$39.1	$3.3	$58.0
Byron_Tract 2	1	$0.1	0.00	$0.0	$0.0	$0.0	$1.0
Byron_Tract 3	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Canal Ranch	3	$0.4	0.00	$0.2	$0.2	$0.0	$3.0
Chipps_Island	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Clifton Court Forebay Water	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Coney_Island	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Deadhorse Island	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Decker_Island	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Discovery_Bay	136	$186.9	1.50	$56.9	$113.6	$9.3	$136.0
Empire_Tract	3	$12.7	0.18	$6.9	$9.4	$0.6	$3.0
Fabian_Tract	9	$6.6	0.09	$2.3	$3.5	$0.3	$9.0
Fay Island	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Glanville_Tract	1	$0.0	0.00	$0.0	$0.0	$0.0	$1.0
Grand Island	43	$58.1	0.44	$20.2	$34.5	$2.9	$43.0
Hastings_Tract 1	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Hastings_Tract 2	1	$0.0	0.05	$0.0	$0.0	$0.0	$1.0

Table A-7
Impacts and Costs to California Businesses Caused by Lost Business Sales by Analysis Zone, per Day of Lost Use 2030 Conditions, 100-Year Floodplain

Analysis Zones	Number of businesses	1000 $ Value of Output	Years Employ-ment	1000 $ Labor income	1000 $ Value added 1.	1000 $ Lost Profit	1000 $ One-time cost if flooded
Holland_Tract	1	$1.2	0.01	$0.4	$0.8	$0.1	$1.0
Hotchkiss_Tract 1	26	$15.5	0.05	$5.2	$8.8	$0.8	$26.0
Hotchkiss_Tract 2	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Jersey_Island	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Jones_Tract	1	$0.0	0.02	$0.0	$0.0	$0.0	$1.0
Kimball Island	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
King_Island	9	$3.4	0.44	$1.2	$2.2	$0.2	$9.0
Liberte Island	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Little Holland Tract	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Mandeville_Island	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
McCormack_Williamson_Tract	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
McDonald_Tract	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Medford_Island	1	$0.0	0.01	$0.0	$0.0	$0.0	$1.0
Merritt Island	2	$0.0	0.07	$0.0	$0.0	$0.0	$2.0
Moore Tract 1	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Moore Tract 2	2	$0.4	0.01	$0.1	$0.2	$0.0	$2.0
Moore Tract 3	1	$0.5	0.00	$0.3	$0.3	$0.0	$1.0
Netherlands 1	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Netherlands 2	1	$2.3	0.04	$0.9	$1.3	$0.1	$1.0
Netherlands 3	46	$54.0	0.26	$15.9	$25.3	$2.7	$46.0
Netherlands 4	6	$1.6	0.07	$0.8	$1.0	$0.1	$6.0
Netherlands 5	1	$1.4	0.01	$0.6	$0.8	$0.1	$1.0
New_Hope_Tract	6	$3.6	0.02	$1.4	$2.2	$0.2	$6.0
Palm-Orwood North	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Palm-Orwood South	2	$0.7	1.05	$0.2	$0.5	$0.0	$2.0
Paradise Junction	2	$3.0	0.89	$1.1	$1.7	$0.2	$2.0

Table A-7
Impacts and Costs to California Businesses Caused by Lost Business Sales by Analysis Zone, per Day of Lost Use 2030 Conditions, 100-Year Floodplain

Analysis Zones	Number of businesses	1000 $ Value of Output	Years Employ-ment	1000 $ Labor income	1000 $ Value added 1.	1000 $ Lost Profit	1000 $ One-time cost if flooded
Pescadero	20	$33.0	0.17	$8.5	$13.6	$1.6	$20.0
Peter Pocket	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Pierson District 1	47	$25.7	0.35	$7.3	$12.9	$1.3	$47.0
Pierson District 2	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Pierson District 3	11	$3.1	0.03	$1.2	$1.8	$0.2	$11.0
Prospect_Island	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Quimby_Island	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
RD 17 Mossdale	162	$1,566.7	6.65	$354.4	$586.3	$78.3	$162.0
Rindge_Tract	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Rio_Blanco_Tract	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Roberts_Island 1	37	$72.7	0.69	$16.3	$28.1	$3.6	$37.0
Roberts_Island 2	1	$1.1	0.00	$0.4	$0.7	$0.1	$1.0
Roberts_Island 3	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Roberts_Island 4	2	$0.1	0.00	$0.0	$0.0	$0.0	$2.0
Rough_and_Ready_Island	34	$485.4	4.69	$152.7	$234.9	$24.3	$34.0
Ryer Island	5	$0.7	0.14	$0.2	$0.4	$0.0	$5.0
Sargent_Barnhart_Tract 1	5	$3.5	0.01	$1.2	$2.3	$0.2	$5.0
Sargent_Barnhart_Tract 2	120	$168.1	1.18	$60.2	$98.8	$8.4	$120.0
Sargent_Barnhart_Tract 3	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Sherman_Island	3	$9.6	0.06	$5.0	$5.6	$0.5	$3.0
Shima_Tract	195	$173.5	1.11	$65.1	$106.8	$8.7	$195.0
Shin_Kee_Tract	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
SM-1	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
SM-123	2	$12.1	0.09	$3.5	$5.3	$0.6	$2.0
SM-124	178	$135.8	1.11	$45.8	$82.7	$6.8	$178.0
SM-131	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0

Table A-7
Impacts and Costs to California Businesses Caused by Lost Business Sales by Analysis Zone, per Day of Lost Use 2030 Conditions, 100-Year Floodplain

Analysis Zones	Number of businesses	1000 $ Value of Output	Years Employ-ment	1000 $ Labor income	1000 $ Value added 1.	1000 $ Lost Profit	1000 $ One-time cost if flooded
SM-132	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
SM-133	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
SM-134	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
SM-198	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
SM-199	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
SM-2	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
SM-201	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
SM-202	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
SM-203	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
SM-204	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
SM-39	7	$22.7	0.29	$6.6	$12.9	$1.1	$7.0
SM-40	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
SM-41	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
SM-42	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
SM-43	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
SM-44	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
SM-45	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
SM-46	1	$0.0	0.00	$0.0	$0.0	$0.0	$1.0
SM-47	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
SM-48	2	$0.0	0.02	$0.0	$0.0	$0.0	$2.0
SM-49	11	$22.8	0.13	$7.0	$11.9	$1.1	$11.0
SM-50	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
SM-51	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
SM-52	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
SM-53	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
SM-54	74	$958.6	5.77	$303.5	$481.8	$47.9	$74.0

Table A-7
Impacts and Costs to California Businesses Caused by Lost Business Sales by Analysis Zone, per Day of Lost Use 2030 Conditions, 100-Year Floodplain

Analysis Zones	Number of businesses	1000 $ Value of Output	Years Employ-ment	1000 $ Labor income	1000 $ Value added 1.	1000 $ Lost Profit	1000 $ One-time cost if flooded
SM-55	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
SM-56	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
SM-57	73	$70.4	0.20	$24.0	$40.8	$3.5	$73.0
SM-58	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
SM-59	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
SM-60	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
SM-84	3	$0.0	0.00	$0.0	$0.0	$0.0	$3.0
SM-85	2	$0.0	0.01	$0.0	$0.0	$0.0	$2.0
Staten_Island	3	$8.2	0.06	$2.0	$3.1	$0.4	$3.0
Stewart_Tract	7	$11.1	0.06	$3.8	$5.9	$0.6	$7.0
Sutter Island	4	$0.3	0.01	$0.1	$0.2	$0.0	$4.0
Terminous_Tract 1	6	$2.7	0.03	$0.9	$1.5	$0.1	$6.0
Terminous_Tract 2	4	$1.6	0.00	$0.7	$1.0	$0.1	$4.0
Terminous_Tract 3	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Twitchell_Island	1	$1.3	0.01	$0.5	$0.8	$0.1	$1.0
Tyler_Island 1	37	$19.1	0.16	$7.8	$11.4	$1.0	$37.0
Tyler_Island 2	11	$94.5	0.26	$14.0	$25.9	$4.7	$11.0
Union_Island 1	13	$22.6	0.26	$10.3	$13.2	$1.1	$13.0
Union_Island 2	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Union_Island 3	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Union_Island 4	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Union_Island 5	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Van_Sickle_Island	13	$22.6	0.26	$10.3	$13.2	$1.1	$13.0
Veale_Tract 1	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Veale_Tract 2	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Veale_Tract 3	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0

Table A-7
Impacts and Costs to California Businesses Caused by Lost Business Sales by Analysis Zone, per Day of Lost Use 2030 Conditions, 100-Year Floodplain

Analysis Zones	Number of businesses	1000 $ Value of Output	Years Employ-ment	1000 $ Labor income	1000 $ Value added 1.	1000 $ Lost Profit	1000 $ One-time cost if flooded
Venice_Island	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Victoria_Island	1	$0.0	0.00	$0.0	$0.0	$0.0	$1.0
Walthal	5	$15.3	0.16	$4.8	$8.7	$0.8	$5.0
Water Body	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Water Canal	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Water Zone 1	63	$106.4	0.77	$42.6	$59.9	$5.3	$63.0
Water Zone 2	18	$45.8	0.34	$8.7	$14.7	$2.3	$18.0
Water Zone 3	21	$23.1	0.16	$7.4	$13.4	$1.2	$21.0
Water Zone 4	28	$40.9	0.27	$16.7	$24.9	$2.0	$28.0
Water Zone 5	28	$40.9	0.27	$16.7	$24.9	$2.0	$28.0
Webb_Tract	28	$40.9	0.27	$16.7	$24.9	$2.0	$28.0
West Sacramento North	1368	$4,615.5	31.82	$1,638.1	$2,489.1	$230.8	$1,368.0
West Sacramento South 1	105	$190.0	1.20	$57.1	$113.5	$9.5	$105.0
West Sacramento South 2	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Winter Island	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Woodward_Island	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Wright-Elmwood_Tract	2	$0.0	0.32	$0.0	$0.0	$0.0	$2.0
Wright-Elmwood_Tract-Sargent Burnhart Tract	652	$2,175.7	15.09	$808.9	$1,298.9	$108.8	$652.0
Zone 120	5	$1.0	0.04	$0.3	$0.6	$0.0	$5.0
Zone 121	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Zone 122	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Zone 126	290	$512.0	2.63	$166.5	$266.3	$25.6	$290.0
Zone 14	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Zone 148	1	$0.0	0.00	$0.0	$0.0	$0.0	$1.0
Zone 155	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Zone 157	167	$98.5	1.17	$34.3	$60.1	$4.9	$167.0

Table A-7
Impacts and Costs to California Businesses Caused by Lost Business Sales by Analysis Zone, per Day of Lost Use 2030 Conditions, 100-Year Floodplain

Analysis Zones	Number of businesses	1000 $ Value of Output	Years Employ-ment	1000 $ Labor income	1000 $ Value added 1.	1000 $ Lost Profit	1000 $ One-time cost if flooded
Zone 158	104	$628.3	2.17	$194.6	$313.2	$31.4	$104.0
Zone 159	157	$1,098.7	6.39	$308.4	$499.8	$54.9	$157.0
Zone 160	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Zone 161	3	$0.2	0.01	$0.1	$0.1	$0.0	$3.0
Zone 162	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Zone 171	1	$5.0	0.03	$2.7	$2.8	$0.2	$1.0
Zone 185	32	$103.6	1.01	$47.1	$62.4	$5.2	$32.0
Zone 186	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Zone 196	10741	$32,544.0	220.60	$12,745.0	$18,882.5	$1,627.2	$10,741.0
Zone 197	15	$10.1	0.05	$3.6	$6.1	$0.5	$15.0
Zone 206	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Zone 207	15	$10.1	0.05	$3.6	$6.1	$0.5	$15.0
Zone 209	18	$262.4	2.24	$70.1	$152.7	$13.1	$18.0
Zone 214	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Zone 216	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Zone 31	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Zone 33	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Zone 36	3	$1.2	0.01	$0.6	$0.7	$0.1	$3.0
Zone 37	75	$117.6	0.83	$42.4	$61.7	$5.9	$75.0
Zone 38	25	$34.8	0.28	$14.0	$20.5	$1.7	$25.0
Zone 61	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Zone 64	14	$0.0	0.00	$0.0	$0.0	$0.0	$14.0
Zone 65	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Zone 68	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Zone 69	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Zone 70	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0

Table A-7
Impacts and Costs to California Businesses Caused by Lost Business Sales by Analysis Zone, per Day of Lost Use 2030 Conditions, 100-Year Floodplain

Analysis Zones	Number of businesses	1000 $ Value of Output	Years Employ-ment	1000 $ Labor income	1000 $ Value added 1.	1000 $ Lost Profit	1000 $ One-time cost if flooded
Zone 74	1	$0.0	0.00	$0.0	$0.0	$0.0	$1.0
Zone 75	4	$2.5	0.02	$0.9	$1.6	$0.1	$4.0
Zone 76	169	$977.8	4.54	$251.4	$378.4	$48.9	$169.0
Zone 77	18	$13.5	0.17	$4.5	$7.5	$0.7	$18.0
Zone 78	1	$0.0	0.00	$0.0	$0.0	$0.0	$1.0
Zone 79	1	$0.0	0.00	$0.0	$0.0	$0.0	$1.0
Zone 80	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Zone 81	2	$31.4	0.22	$9.0	$13.7	$1.6	$2.0
Zone 82	0	$0.0	0.00	$0.0	$0.0	$0.0	$0.0
Zone 90	3	$11.4	0.22	$2.7	$6.1	$0.6	$3.0
TOTAL	15,930	$48,475.6	325.94	$17,892.1	$27,065.4	$2,423.8	$15,930.0

Note:
Totals do not reflect expected losses under specific levee failure conditions because all analysis zones are unlikely to be flooded in a single scenario.
1. Value added is labor income, proprietor's income, other property income and indirect business taxes

Table A-8
Estimates of Positions
for Some State and Local Agencies, 2005–2006

Agency	Positions
Sac Co. General Gov	10449.6
Sac Co. Public Works	1980
Sac Co. General Services	562
CA Dept Water Resources	2587
CA Secretary of State	434
CA State Treas. Office	208
CA Personnel Administration	180
CA Corrections Dept	245
CA Dept. Health Services	5403
CA Dept Mental Health	8495
CA Dept Alcohol and Drugs	305
CA Dept Social Services	3816
CA Dept Aging	118
CA Integrated Waste Mgmt Board	399
CA Toxic Substances Control	951
CA Air Resources Board	978
CA Water Res.Control Board	1409
CA Dept Conservation	573
CA Dept Real Estate	308
CA Energy Commission	446
CA Dept Pesticide Regulation	323

Table A-9
Count of Government Offices and
Economic Cost per Day of Lost Use

URS_Name	Count	Million $ Cost per Day Lost Use
Brannan-Andrus Island	13	$0.080
Byron_Tract 1	1	$0.001
Discovery_Bay	2	$0.002
Grand Island	3	$0.001
Netherlands 3	3	$0.001
Paradise Junction	1	$0.281
Pierson District 1	3	$0.001
Rough_and_Ready_Island	1	$0.003
Shima_Tract	1	$0.002
SM-124	12	$0.139
SM-57	1	$0.003
SM-84	2	$0.004
Sutter Island	1	$0.002
Tyler_Island 1	3	$0.001
Water Zone 1	2	$0.002
West Sacramento North	35	$0.915
Wright-Elmwood_Tract-Sargent Burnhart Tract	5	$0.007
Zone 126	5	$0.011
Zone 159	4	$0.046
Zone 196	394	$12.076
Zone 76	4	$0.124
Zone 90	1	$0.022

Appendix B
Impacts to Crop Production
Based on Flooding of Agricultural Lands

Flooded Crop Impacts

The primary sensitivity of crops to standing water is based on the timing and the length of inundation. As a basic rule, inundation during the dormant season is much less of an issue than if the inundation occurs during the growing season. For example some alfalfa growers in hot regions of California report "scalding" of their crop during summer time irrigations that are applied to border strips or level basins that have slow drainage. This scalding is due to a lack of oxygen diffusion to the rootzone.

Plant growth, including the need for roots to respire, increases rapidly with temperature. In a well-structured soil, under unsaturated conditions there is sufficient oxygen diffusion into the rootzone to support plant growth. Thus the impact of inundation to crop yield and plant health is largely due to the very slow transport of oxygen through water. In addition anoxic conditions in the soil can lead to the release of toxic substances such as manganese.

A search of current literature did not lead to a rich source of data. The topic of the impacts from flooding of agricultural lands does not appear to be highly researched. There were several references to the 2004 southeast Asia tsunami, which did not assess impacts to agricultural land, but rather provided guidance on how to assess impacts. The 1959 Zeeland floods in the Netherlands are also mentioned in the literature. However as with the 2004 tsunami, there is little information about the impacts. Finally, there does not appear to be any analysis or monitoring of the impacts to soil and crops following the 2004 Jones Tract flood.

Table B-1 provides a summary of the information that was available within the reviews. There are several important considerations to keep in mind when reviewing Table B-1. The specifics of the information presented are largely unknown and therefore application to the Delta is questionable. For example, for sorghum there was 90% yield loss after eight days of inundation. However, the growth stage and the ambient weather conditions were not reported. The study for alfalfa was done in Canada at 1000 m elevation – clearly not Delta conditions. By extension the yield loss estimates are not comparable among crops. It is possible that much of this information could be compiled; however it would require considerably more time.

A potential approach for moving forward would be to lump crops into categories such as cereal and grains or tree and vines and then select a range of yield loss for the crop category.

Another aspect of the literature review versus the potential Delta scenarios is that all flooding events in the reviews are assumed to be from fresh water. The physiological impacts to crops from flooding with saline water was mentioned in the Van'tWoudt B.D. and R.H. Hagan review but only as a reference to a paper from 1952.

Table B-1
Crop Yield Loss Due to Flooding

Category	DWR Crop	Source	Critical Period for Flood Risk	Consequence of Flood
Cereal	Grain hay	Luthin	Withstand spring flood 10 to 35 days without excessive damage.	Crop damage not defined.
Cereal	Wheat	Luthin	Withstand spring flood 10 to 35 days without excessive damage.	Crop damage not defined.
Cereal	Barley	Luthin	Greater than 8 days inundation is 100% plant death when inundation is 5 days after germination.	100% plant death after 8 days inundation
	Rice			
	Corn, grain	Skaggs and vanSchilfgaarde	Not stated	60% yield loss after 8 days
	Corn, silage	Skaggs and vanSchilfgaarde	Not stated	60% yield loss after 8 days
	Non-corn silage			
Cereal	Oat hay	Luthin	Withstand spring flood 24 to 28 days without excessive damage.	Crop damage not defined.
Cereal	Grain sorghum	Skaggs and vanSchilfgaarde	Not stated	90% yield loss after 8 days
Grassland/forage	Sudan grass			
	Dry beans	Skaggs and vanSchilfgaarde		
	Safflower			
Grassland/forage	Rye grass	Luthin	Withstand spring flood 10 to 35 days without excessive damage.	Crop damage not defined.
Grassland/forage	Alfalfa hay	Luthin	Withstand spring flood up to 10 w/o crop injury, > 21 days is 100% crop injury.	Crop injury not defined.
Grassland/forage	Irrigated pasture	Luthin	withstand spring flood (Canada)	
	Proc. Tomatoes	Glinski & Stepniewski	Not identified	36% yield loss after 12 days flooding
	Fresh tomatoes	Glinski & Stepniewski	Not identified	36% yield loss after 12 days flooding
	Melons			
	Onions	Glinski & Stepniewski	Not identified	0% yield loss after 12 days flooding
	Sweet corn			
	Potatoes			
	Pumpkins			
	Squash			

Table B-1
Crop Yield Loss Due to Flooding

Category	DWR Crop	Source	Critical Period for Flood Risk	Consequence of Flood
	Asparagus			
	Cucumbers	Glinski & Stepniewski	Not identified	9% yield loss after 12 days flooding
Fruit tree	Apricots	Luthin	Fruit trees are generally susceptible to injury by water logging - more so than many other crops during growing season. During dormant season they can generally withstand waterlogging.	Death after 14 days when grafted to peach rootstock. Other rootstocks (plum cherry) okay
Fruit tree	Apples			
Fruit tree	Cherries			
Fruit tree	Pears	Luthin	can withstand flood during grow season without ill-affects	
Fruit tree	Peaches	Luthin	Fruit trees are generally susceptible to injury by water logging - more so than many other crops	Death after 14 days
Fruit tree	Almonds	Luthin	Fruit trees are generally susceptible to injury by water logging - more so than many other crops	Death after 14 days
Fruit tree	Walnuts	Luthin		Little affect after spring flood
Fruit tree	Wine grapes	Luthin		Little affect after spring flood
Fruit tree	Misc. vegetables			
Fruit tree	Misc. fruits & nuts			
	Misc. field crops			
	Seed crops			
	Nursery Products			

Water Quality Degradation Impact Tables

The excel file "Yield Impact Tables.xls" includes tables that can be used to estimate the changes in farm income and output by URS analysis zone given a change in ambient water quality.[13] These tables are on the worksheet "YIELD IMPACT TABLES." This memorandum describes the tables in the file and how to use them to estimate impacts to farm income and output. Samples of Tables 1 through 6 are presented at the end of this appendix (Tables B-2 through B-7). Because of the dimensions of the actual tables, some of the samples presented in this appendix have been truncated to fit the width of the page.

[13] For purposes of this analysis, farm income is defined as gross revenue less variable production expense. This is also sometimes referred to as contributions to fixed costs of production.

Table Descriptions

TABLE 1: YIELD % OF NORMAL, SALINITY IMPACT ONLY: This table provides the estimated change in yield for eight crop groups caused by increases in irrigation water salinity. Salinity level, measured in dS/m, ranges between 0.5 and 33.5, increasing in increments of 0.5 dS/m. Most crop yields decline to zero between 10 and 15 dS/m. The water quality range is extended to 33.5 dS/m because of the high salt tolerance of asparagus, the principal truck crop grown in the Delta. The yield impact model generating the estimates was developed by Dr. Mark Roberson, and is based on the Mass-Hoffman relationships. Yield impact for each crop group is an acreage-weighted average of the crops comprising the group.

TABLE 2: YIELD % OF NORMAL, SALINITY + CLHORIDE IMPACT: This table is similar to Table 1, but estimates the maximum yield impact due to the combined affects of salinity and chloride. Results are based on the yield impact model developed by Dr. Mark Roberson. Yield impact for each crop group is an acreage-weighted average of the crops comprising the group. Estimated reduction in yield in Table 2 is the same or greater than the reduction estimated in Table 1 because of the chloride impact.

TABLE 3: LOSS OF FARM OUTPUT, SALINITY IMPACT ONLY ($/ACRE, rounded nearest $100): This table uses yields from Table 1 to report reductions in farm output.

TABLE 4: LOSS OF FARM OUTPUT, SALINITY + CHLORIDE IMPACT ($/ACRE, rounded nearest $100): This table is the same as Table 3, except that the reduction in output is based on the combined impact of salinity and chloride from Table 2.

TABLE 5: ANALYSIS ZONE CROP ACREAGE: This table provides estimated acreage for each crop group for the 96 URS analysis zones having 100 acres or more of irrigated acreage. Construction of the acreage estimates is described in the Economic Team's technical report.

TABLE 6: MONTHLY IRRIGATION WEIGHTS: This table provides the percent of annual irrigation water applied each month by crop group. The monthly irrigation shares were developed from UC Extension Cost and Return Studies using a representative crop within each crop group.

Use of Tables to Estimate Income/Output Impacts

Use of the tables to estimate Delta agriculture income/output impacts requires that a 96 x 12 matrix of average monthly salinity by URS analysis zone first be calculated for each year of impact using the output from the WAM model. Salinity should be expressed in dS/m. Call this matrix **S**. It also requires a 96 x 1 binary vector indicating the flood state of each analysis zone (1=flooded, 0=not flooded). Call this vector **F**.

Let **W** be the 8 x 12 matrix of irrigation weights in Table 6. Define **Q** as the 96 x 8 matrix of average irrigation water quality by crop group for each URS analysis zone.

$\mathbf{Q} = \mathbf{SW'}$

Round each element q_{ij} in **Q** to the nearest 0.5 dS/m.

Step through the vector **F**. If $f_i = 1$, then set the corresponding row in **Q** to 0.5 dS/m. This will prevent calculation of water quality impacts for flooded analysis zones.

Generate the 96 x 8 matrix **Q***, where

Q* = 2**Q**

Let **L’** be a 67 x 8 matrix of per acre crop output losses (e.g., the transpose of Table 4). Generate the 96 x 8 matrix **L***, where

$l^*_{ij} = l'_{i^*j}$ where $i^* = q^*_{ij}$ in the matrix **Q***.

Let **A** be the 96 x 8 matrix of analysis zone crop acreages (e.g., Table 5). Multiply each element in **A** by its corresponding element in **L***, call the resulting 96 x 8 matrix **C**. The column sums of **C** are the water quality losses for each crop group, the row sums are the water quality losses for each analysis zone, and the sum of all elements is the total loss for the Delta.

$$C_i = \sum_j c_{ij} \text{ = loss for analysis zone i}$$

$$C_j = \sum_i c_{ij} \text{ = loss for crop group j}$$

$$C = \sum_i \sum_j c_{ij} \text{ = total water quality loss}$$

Sample Water Quality Tables

Tables B-2 through B-7 provide examples of Tables 1 through 6. The columns of some of these tables have been truncated to fit on the report page. Salinity levels for the actual tables extend to 32 dS/m.

Table B-2
Yield % Of Normal, Salinity Impact Only

	ECW-Irrigation Water (Ds/M)					
Crop	0.50	1.00	1.50	2.00	2.50	3.00
Alfalfa	100.0	100.0	97.2	91.7	86.2	80.7
Field Crops	100.0	99.3	91.7	83.1	74.5	65.9
Grain	100.0	100.0	100.0	100.0	100.0	100.0
Orchards	100.0	99.5	81.4	63.2	45.1	27.0
Rice	100.0	100.0	100.0	97.6	88.0	78.4
Tomato	100.0	100.0	93.6	86.4	79.1	71.8
Truck	100.0	99.6	96.9	91.3	85.5	79.1
Vineyards	100.0	99.0	91.4	83.7	76.0	68.3

Table B-3
Yield % of Normal, Salinity + Chloride Impact

	ECw-irrigation water (dS/m)					
CROP	0.50	1.00	1.50	2.00	2.50	3.00
ALFALFA	100.0	96.8	88.5	80.3	71.9	63.4
FIELD CROPS	99.8	89.3	76.1	63.0	49.8	37.7
GRAIN	100.0	100.0	100.0	100.0	97.9	91.2
ORCHARDS	100.0	99.5	81.4	63.2	45.1	27.0
RICE	100.0	100.0	91.2	76.2	61.3	46.3
TOMATO	100.0	100.0	87.6	75.2	62.7	50.3
TRUCK	100.0	97.9	91.6	84.1	76.6	68.5
VINEYARDS	100.0	99.0	91.4	83.7	76.0	68.3

Table B-4
Loss of Farm Output Salinity Impact Only
($/Acre, Rounded Nearest $100)

	ECw-irrigation water (dS/m)					
Crop	0.50	1.00	1.50	2.00	2.50	3.00
Alfalfa	0	0	0	100	100	200
Field Crops	0	0	0	100	100	200
Grain	0	0	0	0	0	0
Orchards	0	0	1100	2200	3200	4300
Rice	0	0	0	0	100	200
Tomato	0	0	200	400	500	700
Truck	0	0	100	300	400	600
Vineyards	0	0	400	700	1000	1300

Table B-5
Loss of Farm Output Salinity + Chloride Impact ($/Acre, Rounded Nearest $100)

	ECw-irrigation water (dS/m)					
Crop	0.50	1.00	1.50	2.00	2.50	3.00
Alfalfa	0	0	100	200	200	300
Field Crops	0	100	100	200	300	300
Grain	0	0	0	0	0	0
Orchards	0	0	1100	2200	3200	4300
Rice	0	0	100	200	300	500
Tomato	0	0	300	600	1000	1300
Truck	0	100	200	500	700	900
Vineyards	0	0	400	700	1000	1300

Table B-6
Analysis Zone Crop Acreage

URS_Id	URS_Name	Alf.	Field Crops	Grain	Orch	Rice	Tomato	Truck	Vineyards
4	Webb_Tract	0	2620	1814	0	0	0	0	0
5	Empire_Tract	0	2052	610	0	0	0	449	0
7	King_Island	1375	227	59	233	120	599	307	167
9	Jersey_Island	471	0	0	0	0	0	0	0
10	Bethel_Island	163	9	0	42	0	0	192	71
11	Quimby_Island	0	552	0	0	0	0	0	0
12	McDonald_Tract	451	978	1097	12	0	0	2365	8
13	Holland_Tract	82	540	443	0	0	0	0	0
14	Zone 14	77	4	0	20	0	0	91	34
15	Bacon_Island	0	3180	861	0	0	0	1108	0
16	Palm-Orwood North	222	1338	0	0	0	0	648	0
17	Jones_Tract	815	4398	1652	0	0	0	4535	0
19	Woodward_Island	0	1272	135	0	0	0	244	0
20	Palm-Orwood South	385	1376	400	0	0	0	0	0
21	Victoria_Island	1021	2784	704	0	0	0	2168	0
32	Coney_Island	497	231	164	0	0	0	0	0
61	Zone 61	26	41	0	0	5	8	5	20
62	Tyler_Island 1	8	156	72	11	0	21	34	2
63	Tyler_Island 2	2037	3277	0	0	392	618	395	1593
68	Zone 68	1891	594	125	18	0	0	51	135
70	Zone 70	2986	938	198	29	0	0	81	213
72	Peter Pocket	886	278	59	9	0	0	24	63
75	Zone 75	447	718	0	0	86	135	87	349
76	Zone 76	275	442	0	0	53	83	53	215
78	Zone 78	96	155	0	0	19	29	19	75
79	Zone 79	1259	395	83	12	0	0	34	90
80	Zone 80	1112	349	74	11	0	0	30	79
81	Zone 81	1487	467	98	14	0	0	40	106
83	Hastings_Tract 2	1828	1866	365	0	0	0	0	0
86	Terminous_Tract 1	178	712	257	0	0	84	120	47
87	Terminous_Tract 2	1248	4998	1805	0	0	590	840	328
88	Moore Tract 3	4845	1522	321	47	0	0	131	346
89	Moore Tract 1	1041	327	69	10	0	0	28	74
106	Roberts_Island 2	45	7	2	8	4	20	10	6
108	Hotchkiss_Tract 1	1523	0	0	0	0	0	0	0
109	Hotchkiss_Tract 2	64	3	0	16	0	0	75	28
112	Union_Island 2	38	40	9	2	0	14	13	2
113	Union_Island 3	233	244	53	14	0	87	78	14
114	Union_Island 4	210	220	48	13	0	79	71	13
115	Roberts_Island 4	1832	2097	1114	58	0	689	1221	236
117	Union_Island 1	7380	7734	1673	449	0	2768	2487	458
118	Pescadero	2808	464	121	476	245	1222	628	342
119	Paradise Junction	1411	233	61	239	123	614	316	172
120	Zone 120	1694	280	73	287	148	737	379	206
121	Zone 121	480	79	21	81	42	209	107	58

Table B-6
Analysis Zone Crop Acreage

URS_Id	URS_Name	Alf.	Field Crops	Grain	Orch	Rice	Tomato	Truck	Vineyards
123	SM-123	107	33	7	1	0	0	3	8
125	Veale_Tract 1	28	38	7	61	0	42	10	2
126	Zone 126	2328	384	101	395	203	1014	521	284
127	Byron_Tract 1	1181	1681	566	97	0	386	500	0
128	Byron_Tract 2	159	226	76	13	0	52	67	0
129	Veale_Tract 2	214	287	49	461	0	313	77	16
137	Netherlands 1	0	540	205	7	0	123	15	133
138	Netherlands 2	216	513	195	6	0	117	14	127
141	Merritt Island	247	1302	416	473	0	320	29	1705
142	Netherlands 3	4023	9568	3634	116	0	2186	268	2364
143	Rindge_Tract	0	4513	321	0	0	0	1679	0
144	Mandeville_Island	42	1379	663	0	0	0	4	226
145	Netherlands 4	1019	2424	921	29	0	554	68	599
146	Sutter Island	197	611	39	1259	0	52	0	224
147	Grand Island	1867	8186	2174	2293	0	959	207	40
148	Zone 148	538	866	0	0	104	163	104	421
149	Pierson District 1	585	3420	477	1940	0	645	0	1581
150	Venice_Island	0	2752	0	0	0	0	6	0
154	Roberts_Island 1	6571	7522	3995	208	0	2472	4377	846
161	Zone 161	1325	219	57	225	116	577	296	161
162	Zone 162	213	35	9	36	19	93	48	26
163	Fabian_Tract	1245	1065	74	43	0	1140	2670	0
164	Stewart_Tract	1441	1221	513	310	0	609	401	0
165	Walthal	765	126	33	130	67	333	171	93
166	RD 17 Mossdale	2474	408	107	420	216	1077	553	301
169	McCormackWilliams	0	736	260	0	0	475	0	0
170	Glanville_Tract	1829	1133	1116	617	0	282	0	1407
171	Zone 171	304	490	0	0	59	92	59	238
172	New_Hope_Tract	87	2891	685	282	0	1253	335	1850
173	Deadhorse Island	0	0	0	0	0	190	0	0
174	Staten_Island	0	4565	1854	0	13	1717	554	0
175	Canal Ranch	378	1848	440	0	0	1211	0	1186
176	Brack_Tract	568	2068	844	4	0	241	0	691
177	Bouldin_Island	0	3505	1824	0	0	0	0	0
178	Brannan-Andrus	590	8659	1739	791	0	0	766	681
179	Twitchell_Island	486	1908	705	14	0	0	0	0
181	Sherman_Island	3446	3771	1567	0	0	0	6	2
182	Shin_Kee_Tract	543	612	189	0	0	186	73	0
183	Rio_Blanco_Tract	249	324	544	0	0	47	153	0
184	Bishop_Tract	573	705	144	4	0	114	586	0
186	Zone 186	120	20	5	20	10	52	27	15
187	Shima_Tract	765	290	270	275	0	31	35	0
190	Wright-Elmwood	0	708	640	0	0	381	141	0
192	Moore Tract 2	13313	0	88	0	1952	0	744	2836
194	West Sacramento S 1	2222	0	15	0	326	0	124	473
196	Zone 196	191	307	0	0	37	58	37	149

Table B-6
Analysis Zone Crop Acreage

URS_Id	URS_Name	Alf.	Field Crops	Grain	Orch	Rice	Tomato	Truck	Vineyards
197	Zone 197	496	799	0	0	96	151	96	388
210	Ryer Island	865	4184	3194	462	0	2125	0	620
211	Prospect_Island	24	279	131	0	0	0	3	0
216	Zone 216	52	9	2	9	5	23	12	6
217	Netherlands 5	74	177	67	2	0	40	5	44

Table B-7
Monthly Irrigation Weights

Crop	1	2	3	4	5	6	7	8	9	10	11	12
Alfalfa	0.00	0.00	0.00	0.10	0.10	0.20	0.20	0.20	0.10	0.10	0.00	0.00
Field Crops	0.00	0.00	0.17	0.00	0.09	0.27	0.27	0.19	0.00	0.00	0.00	0.00
Grain	0.00	0.00	0.33	0.33	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Orchards	0.00	0.00	0.00	0.10	0.20	0.20	0.20	0.19	0.10	0.00	0.00	0.00
Rice	0.00	0.00	0.00	0.00	0.20	0.20	0.20	0.20	0.20	0.00	0.00	0.00
Tomato	0.00	0.00	0.20	0.09	0.18	0.27	0.27	0.00	0.00	0.00	0.00	0.00
Truck	0.00	0.00	0.05	0.09	0.09	0.20	0.20	0.20	0.20	0.00	0.00	0.00
Vineyards	0.00	0.00	0.00	0.11	0.17	0.19	0.21	0.18	0.12	0.03	0.00	0.00

Appendix C
Delta Island Recreation

Table C-1
Delta Island Recreation Inventory

Island	Recreation Zone	Small Marinas	Medium Marinas	Large Marinas	Marina Berths	Fishing Access Sites
City of Sacramento	A		5	1	860	1
Merritt Island	A				0	
Netherlands	A	2	2		260	1
Hastings Tract	B				0	
Prospect Island	B		1		108	
Yolo Bypass	B				0	
Brack Tract	C				0	
Brannan-Andrus Island	C	8	6	6	2740	10
Canal Ranch Tract	C				0	
Deadhorse Island	C	2			44	
Glanville Tract	C				0	
Grand Island	C	3	1		174	
McCormack Williamson Tract	C				0	
New Hope Tract	C				0	
Pierson District	C				0	1
Ryer Island	C				0	1
Staten Island	C				0	
Sutter Island	C	1			22	1
Sycamore Island	C				0	
Tyler Island	C		1		108	1
Bacon Island	D				0	
Bethel Island	D	6	7		889	
Bouldin Island	D				0	
Bradford Island	D				0	
Brown Island	D				0	1
Chipps Island	D				0	
Decker Island	D				0	
Franks Tract	D				0	1
Holland Tract	D	1		1	341	
Hotchkiss Tract	D	9	1		306	
Jersey Island	D				0	
Kimball Island	D				0	1
Little Franks Tract	D				0	
Little Mandeville Island	D				0	
Manderville Island	D				0	
Neville Island	D				0	
Palm-Orwood Tract	D		2		216	
Rhode Island	D				0	
Sherman Island	D	2	3		368	1
Twitchell Island	D	1			22	
Van Sickle Island	D				0	
Veale Tract/Antioch	D		1	4	1385	6

Table C-1
Delta Island Recreation Inventory

Island	Recreation Zone	Small Marinas	Medium Marinas	Large Marinas	Marina Berths	Fishing Access Sites
Venice Island	D				0	
Webb Tract	D				0	
Winter Island	D				0	
Bishop Tract	E				0	
Empire Tract	E		1		108	
King Island	E		1	2	746	
Little Tinsley Island	E				0	
Lower Jones Tract	E	1			22	
Lower Roberts Island	E	2	1	2	790	
McDonald Island	E	1			22	
Medford Island	E				0	
Mildred Island	E				0	
Ridge Tract	E			1	319	1
Rio Blanco Tract	E				0	
Rough and Ready Island	E				0	
Sargent Barnhart Tract	E		2		216	1
Shima Tract	E			1	319	1
Shin Kee Tract	E				0	1
Terminous Island	E	1		1	341	1
Upper Jones Tract	E				0	
Woodward Island	E				0	
Wright-Elmwood Tract	E		2		216	1
Byron Tract	F	1		1	341	1
Coney Island	F				0	
Fabian Tract	F		1		108	
Middle Roberts Island	F		1		108	
Stewart Tract	F	1			22	
Union Island	F				0	
Upper Roberts Island	F	1			22	1
Victoria Island	F				0	

Table C-2
2005 Spatial and Temporal Distribution of Delta Boating Recreation
(# of Visitor Days/Month or Season/Zone)

	Delta Recreation Zone						
Month	**A**	**B**	**C**	**D**	**E**	**F**	**Total**
Jan	46,717	16,566	97,248	174,593	112,979	44,572	492,675
Feb	56,383	19,993	117,368	210,716	136,354	53,794	594,608
Mar	90,212	31,989	187,789	337,146	218,167	86,070	951,373
Apr	122,431	43,413	254,857	457,555	296,083	116,809	1,291,148
May	162,704	57,694	338,691	608,067	393,479	155,233	1,715,868
Jun	214,254	75,973	445,999	800,721	518,146	204,416	2,259,510
Jul	248,084	87,969	516,420	927,151	599,958	236,692	2,616,275
Aug	231,975	82,256	482,886	866,946	561,000	221,323	2,446,387
Sep	193,312	68,547	402,405	722,455	467,500	184,436	2,038,655
Oct	127,264	45,127	264,917	475,616	307,771	121,420	1,342,115
Nov	77,325	27,419	160,962	288,982	187,000	73,774	815,462
Dec	40,273	14,281	83,834	150,512	97,396	38,424	424,720
Total	1,610,936	571,225	3,353,376	6,020,461	3,895,834	1,536,964	16,988,796
Season							
Winter	143,373	50,839	298,450	535,821	346,729	136,790	1,512,003
Spring	375,348	133,095	781,337	1,402,767	907,729	358,113	3,958,389
Summer	694,313	246,198	1,445,305	2,594,819	1,679,105	662,432	7,322,171
Fall	397,901	141,092	828,284	1,487,054	962,271	379,630	4,196,233
Total	1,610,936	571,225	3,353,376	6,020,461	3,895,834	1,536,964	16,988,796

Delta Boating/Fishing Impact Model

A model was developed to estimate the economic effects of island flooding on Delta boating and fishing. The functional form of the model is shown by equation 1.

$$(1) \qquad \Delta CS(m,i,\mathbf{d}) = \left(1-\delta(m,i,\mathbf{d})\right)\cdot ub\sum_z\sum_i v_z(m,d_i)\cdot\frac{b_{i,z}}{B_z},$$

where **i** is the vector of flooded islands, **d** is the vector of island closure durations, $b_{i,z}$ is the number of boat berths located on island i in zone z, and B_z is the total number of boat berths in DPC recreation zone z. The model's fundamental assumption is that the loss of boating visitor-days will be proportional to the loss of boat berths due to island flooding. This assumption is adopted because of the similar zonal distributions for visitor-days and boat berths (Figure 5).[14] ∂(m,**z,d**) is a function expressing the percentage of affected recreation visitor days that shift to other parts of the Delta or outside the Delta due to the island closures and is determined by

$$(2) \qquad \delta(m,i,\mathbf{d}) = 0.75\cdot\frac{\sum_i v_i(m,d_i)}{T(m,\mathbf{d})},$$

[14] While theoretically plausible, this assumption is not based on empirical evidence.

where T(m,**d**) is the total potential visitor days for all DPC zones over the average duration of outage. This function results in a decreasing amount of recreation substitution as the number of closed islands and average duration of closure increases. When the entire Delta is closed to recreation the model assumes a maximum of 25% of Delta recreation will shift to sites outside the Delta. ∂(m,**i,d**), while theoretically plausible, is not empirically derived.

The change in within-Delta and outside-Delta recreation-related business income, value added, and employment can be calculated by multiplying the change in visitor-days by trip expenditures and the appropriate impact multiplier per equation 3.

(3) $$\Delta I(m,i,\mathbf{d}) = \left(1-\delta(m,i,\mathbf{d})\right)\cdot n\cdot\left(FL\cdot M_{FL} + TR\cdot M_{TR} + OE\cdot M_{OE}\right)\cdot\sum_i v_i(m,d_i)$$

where ΔI is the change in the impact indicator (e.g., output, income, employment, or jobs), FL is food and lodging expenditures, TR is travel expenditures, OE are other trip expenditures, the M variables are the associated impact multipliers from Goldman et al. (1998), and n is a random variable distributed N(1,0.175).[15]

[15] The standard deviation of 0.175 for the variable n is taken from the standard error for average trip expenditures reported in USFWS (2003 a). The random variable n is used to transform average trip expenditures from Goldman, et al. into random variables.

Appendix D
South of Delta Agricultural Water Users

Analysis of Agricultural Use of Groundwater in the Delta Export Regions

The following presents results of the Delta Risk Management Strategy (DRMS) Analysis of Agricultural Use of Groundwater in the Delta Export Regions based on URS' Scope of Work and Cost Estimate dated June 13, 2006, and M. Cubed's October 10, 2006, Memorandum Re: Groundwater Analysis. Results are presented in direct response to the four primary groundwater information requirements and two additional groundwater information requirements outlined in the October 10, 2006, M. Cubed memorandum, as follows.

Question #1:	Maximum monthly groundwater pumping estimates.
Question #2:	Potential to increase monthly groundwater pumping.
Question #3:	Estimated cost to install new wells.
Question #4:	Change in average pumping cost due to pumping increase.
Additional Question #1:	Amount of farmed irrigated acreage without access to groundwater.
Additional Question #2:	Level of total dissolved solids and any other limiting constituents that would affect yield or prevent use of groundwater on important crops, by region.

URS presented preliminary results during a meeting with the Economics Team on November 13, 2006. Revisions, as discussed during the meeting and summarized in URS' memorandum dated November 14, 2006, were incorporated into this memorandum and its attachments. Note that the attached tables are extensively footnoted to clarify assumptions, technical factors, and the derivation of the calculations.

The following is a summary of our final results summarized for the applicable CVPM regions, 10 and 13 through 21, which correspond to C2VSIM subareas.

Question #1: Maximum monthly groundwater pumping estimates

Maximum monthly groundwater pumping rate estimates were based on data provided by two primary sources: public water agency questionnaire responses and the State of California Department of Water Resources (DWR).

URS developed and sent a transmittal letter and questionnaire to a list of 73 Central Valley Project and State Water Project agricultural water agencies within the targeted DRMS Delta export impact area on August 18, 2006. URS received 32 responses, including 23 completed questionnaires. Nine agencies responded with a phone call, a letter or an email, but did not complete the questionnaire. A summary of the agencies that received a questionnaire and those that responded is presented in Table 1. Copies of the completed questionnaires and a compilation of questionnaire responses can be provided upon request.

The results for Question #1 are summarized on Table 2. Maximum monthly pumping rates were estimated from the available questionnaire responses based on the reported number of currently operational wells and the reported average pumping rate. Columns

Table 1 Questionnaire Response Tracking for Delta Risk Management Strategy: Analysis of Agricultural Use of Groundwater

District/Agency	Received	Date	Note
Questionnaire w no name	X	9/29/03	
Antelope Valley-East Kern WA			
Arvin-Edison WD	X	9/14/06	
Banta-Carbona ID			
Belridge WSD	X	9/11/06	
Berrenda Mesa WD	X	8/28/06	
Broadview WD	X	9/14/06	Email only, no questionnaire
Buena Vista WSD			
Byron-Bethany ID			
Castaic Lake WA			
CaweloWD			
Centinella WD	X	8/22/06	Email only, no questionnaire
Central Calif ID	X	9/29/06	No questionnaire. See Columbia Canal
Chowchilla WD			
City of Tracy			
Columbia Canal Co.	X	9/29/06	Email only, no questionnaire
Del Puerto WD	X	9/14/06	
Delano-Earlimart ID			
Dudley Ridge WS	X	8/28/06	Email only, no questionnaire
Eagle Field WD			
Empire West Side ID			
Exeter ID	X	9/11/06	
Firebaugh Canal WD	X	8/21/06	
Fresno ID	X	9/5/06	
Fresno Slough WD			
Grassland WD			
Gravelly Ford WD			
Ivanhoe ID	X	9/8/06	
James ID	X	9/20/06	
Kern Delta WD			
Kern-Tulare WD	X	9/26/06	Combined with Rag Gulch
Laguna WD			
Linday-Strathmore ID			
Lindmore ID			
Lost Hills WD	X	10/4/06	Letter only no questionnaire
Lower Tule River ID			
Madera ID			
Mercey Springs WD			
Orange Cove ID			
Oro Loma WD			

Table 1 Questionnaire Response Tracking for Delta Risk Management Strategy: Analysis of Agricultural Use of Groundwater

District/Agency	Received	Date	Note
Pacheco WD			
Pajaro Valley WMA			
Panoche WD	X	9/25/06	
Patterson ID			
Pixley ID			
Pleasant Valley ID			
Porterville ID			
Rag Gulch WD	X	9/26/06	Resp. combined with Kern-Tulare
RD 1608	X	9/20/06	
Rosedale-Rio Bravo WSD	X	9/1/06	
San Benito CWD	X	10/20/06	No questionnaire – CD with 2005 Annual GW report
San Luis Canal Co.	X	10/2/06	
San Luis WD			
Santa Clara Valley WD			
Saucelito ID			
Semitropic WSD	X	9/7/06	Correction received 11/10/06
Shafter-Wasco ID	X	9/29/06	9/29/06
South San Joaquin ID			
Stone Corral ID			
Tea Pot Dome WD			
Tehachapi-Cummings CWD			
Tejon-Castaic WD	X	?	No questionnaire. Spoke to agency
Terra Bella ID			
Tranquillity ID	X	9/18/06	
Tri-Valley WD			
Tulare ID	ID		
Tulare Lake Basin WSD			
Turner Island WD	X	9/14/06	No questionnaire. Letter only
West Kern WD	X	8/22/06	
West Side ID			
West Stanislaus ID	X	9/29/06	
Westlands ID	X	9/7/06	
Wheeler Ridge-Maricopa WSD	X	9/22/06	
Widren WD			
Total Received	**32**		

2 and 3 of Table 2 summarize these estimates for each responding public water agency. However, water agencies within Subareas 13, 16, 17, and 18 either did not complete questionnaires or did not provide either operational well or pumping rate data. It should

be noted that Subarea 16 is not significantly dependent on Delta export water and Subarea 17 is primarily dependent on Friant-Kern contractors.

Maximum monthly pumping rates were also estimated from unconfined groundwater elevation data provided by DWR, San Joaquin District, in Fresno, California. Unconfined groundwater elevation data collected annually during the spring in the San Joaquin River and Tulare Lake Basin hydrologic regions were provided in GIS format from 1985 to 2005. It should be noted that unconfined groundwater elevation data do not cover the entirety of any subarea and geographic coverages vary slightly by year. Groundwater elevation data for the confined, sub Corcoran Clay aquifer, were not available from DWR.

Groundwater elevation data from the most recent drought period, 1987 to 1992, were used to approximate the change in groundwater elevation that may occur due to an increase in ground water pumping in the event of a catastrophic levee failure and cutoff of Delta export water. As summarized in columns 4 through 8 of Table 2, changes in aquifer storage during the drought were estimated based on groundwater elevation changes. Average groundwater elevations were estimated in GIS for each subarea in 1986, 1987, 1991, and 1992. Changes in elevation between 1986 and 1987 represent the base year change in elevation, before the drought started. Elevation changes during the last year of the drought, 1991 to 1992, represent the period of the drought in which peak groundwater pumping occurred. Consequently, the difference in the groundwater elevation change between 1992/1991 and 1987/1986 represents an estimate of the maximum groundwater elevation change caused by the drought. This calculation assumes that the net change in groundwater elevation is due to groundwater pumping only. Neither natural groundwater inflow and outflow nor aquifer recharge is taken into account due to a lack of reliable data.

Based on the change in groundwater elevations, groundwater volumes were estimated based on the area, acreage, of each subarea and specific yield of the aquifer as reported by DWR. Subarea acreage was provided by DWR and specific yield data were obtained from DWR's preliminary C2VSIM model. The annual change in volume, the change in storage, was then proportioned over the entire subarea and monthly pumping rates were estimated under the assumption that maximum monthly pumping rates range from 20% to 25% of annual pumping. Only limited unconfined groundwater elevation data are available in Subarea 14 (Westlands WATER DISTRICT which is reliant on the confined aquifer). Therefore, unconfined storage is not estimated for Subarea 14.

The maximum monthly pumping rates estimated from both public water agency questionnaire responses and from DWR groundwater elevation data are summarized in Table 2.

Question #2: Potential to increase monthly groundwater pumping

Estimates of the potential to increase monthly pumping for each subarea are summarized on Table 3. These calculations assume that the potential to increase monthly pumping is solely dependent on the ability to install new wells with pumps. Although the questionnaire requested information from agencies on the number of non-operational wells, this information was not used to estimate the potential to increase pumping. Based on information obtained from drilling and pump companies, rehabilitating non-functional wells was determined to be unreliable and impractical.

Calculations were based on the assumption that either “deep” or “shallow” wells would be installed. Depth to groundwater on the east side of the San Joaquin Valley is shallower than on the west side. Therefore, it was assumed that shallow wells, approximately 500 to 700 feet deep, would be necessary on the east side of the San Joaquin Valley (Subareas 13, 16, 17, 18, and 20). Deep wells, approximately 1,200 to 1,500 feet deep, would be necessary on the west side of the San Joaquin Valley (Subareas 10, 14, 15, 19, and 21).

Information obtained from well drilling and pump companies indicated that the availability of pumps might be more of a limiting factor than the availability of well drilling rigs in completing new wells with pumps. URS contacted four drilling and pump companies: WDC Exploration and Wells in Woodland, California (WDC); Layne Christensen Company in Fontana, California (Layne); West Side Pump Co. in San Joaquin, California (West Side Pump); and Calwest Rain, Inc. in Kerman, CA (Calwest Rain). Based on information from WDC and Layne, it will take approximately four weeks to drill a deep well (~1,200 to 1,500 feet) and approximately two weeks to drill a shallow well (~500 to 700 feet). Based on information from West Side Pump and Calwest Rain, it will take approximately six to nine months to build, install and complete a shallow well with a pump and approximately nine to twelve months to do the same for a deep well due to limitations to build the pumps.

Based on this limitation, it was estimated that approximately 24 shallow wells with pumps could be installed in each subarea on the east side of the San Joaquin Valley and approximately 12 deep wells could be installed in each subarea on the west side of the San Joaquin Valley within the first six months following a levee event. Consequently, a total of 180 wells could theoretically be installed in the first six months following cutoff of Delta export water.

The estimated theoretical rate to install new wells with pumps was assumed to be constant so that in one year a total of 360 wells, 48 shallow and 24 deep in each subarea, and a total of 720 wells, 96 shallow ands 48 deep in each subarea, could be installed in two years. This estimate was based on the theoretical maximum capability data provided by well drillers with consideration for practical efficiency or longer-term sustainable capabilities. The practical ability to install new wells fully equipped with pumps and drivers was estimated based on the assumption that well installation efficiency is 65% due to unpredictable equipment failure, pump, driver, and power availability and pumping schedules. Consequently, the number of new wells with pumps that could practically be installed is 120 in 6 months, 235 in 1 year, and 465 in 2 years. It was assumed that new wells are evenly distributed throughout each subarea.

According to Layne and others, the typical production rate for a new agricultural well ranges from 1,500 to 3,000 gallons per minute (gpm). Therefore, an average pumping rate of 2,250 gpm was used to estimate the average monthly pumping rate based on the practical ability to install new wells with pumps. As shown on Table 3, the potential to increase monthly pumping is estimated to be approximately 36,000 acre-feet (AF) during the first 6 months, 71,000 AF during the first year, and 143,000 AF during the first 2 years following a levee event and loss of Delta export water.

Question #3: Estimated cost to install new wells

Estimated costs to install new wells are based on the practical ability to install new wells with pumps and drivers within the first six months, one year, and two years following a levee event, from Question #2, and the estimated costs to install new wells with pumps. Results are summarized in Table 4.

Estimated costs to install new wells with pumps were obtained from WDC, Layne, and Calwest and include the costs of drilling, pumping equipment, and pump installation. As with Question #2, subareas were separated into those that would require shallow wells (Subareas 13, 16, 17, 18, and 20) and those that would require deep wells (Subareas 10, 14, 15, 29, and 21). Estimates for shallow and deep wells are summarized in Table 7.

As shown on Table 4, average costs to install new wells was estimated to be approximately $55 million during the first six months, $109 million during the first year, and $214 million during the first two years following a levee event and loss of Delta export water.

Question #4: Change in average pumping cost due to pumping increase

The change in average pumping cost due to an increase in pumping is based on groundwater elevation data provided by DWR and a functional relationship developed between pumping cost and pumping lift. The results are summarized in Table 5.

The change in groundwater elevation during the last year of the drought, 1991 to 1992, was used to approximate the change in groundwater elevation and resultant pumping lift, that may occur following the loss of Delta export water. Similar to Question #1, this assumes that maximum pumping occurred during the last full hydrologic year of the drought, 1991 to 1992, and that similar pumping rates would be achieved immediately following a levee event and loss of Delta export water. Following a similar procedure as described for Question #1, an average groundwater elevation was estimated for each subarea in both 1991 and 1992. The difference in groundwater elevation was used to approximate the change in groundwater volume based on the acreage of each subarea and the specific yield of the aquifer. This volume was proportioned over the entire subarea based on the portion of the subarea for which there were groundwater elevation data. Consequently, an annual volume change was calculated for each subarea.

A functional relationship was developed between pumping cost and pumping lift to establish an incremental cost per acre-foot pumped per foot of groundwater elevation change ($/AF/ft.). This calculation was based on Pacific Gas & Electric Company's (PG&E's) rate AG-1 effective September 1, 2006. As summarized in column 8 of Table 5, the incremental cost, assuming an overall plant efficiency (OPE) of 65%, was determined to be $0.292 per AF per foot of groundwater elevation change.

The change in average pumping cost was calculated based on the average groundwater elevation change and the incremental pumping cost. As noted on Table 5, the approximate groundwater volume change for Subarea 14 was calculated based on average groundwater elevation and pumping data for the confined aquifer as reported by Westlands Water District. The data was obtained from the Deep Groundwater Conditions Report, December 2005, published by Westlands Water District, and dated March 2006.

The groundwater volume change for Subarea 14 is represented by the pumping volume (600,000 AF) between 1991 and 1992.

As shown on Table 5, the change in average pumping costs range from approximately $47,000 in Subarea 17 to over $5,000,000 in Subarea 14.

Additional Questions 1 and 2: Amount of farmed irrigated acreage without access to groundwater and level of total dissolved solids and any other limiting constituents that would affect yield or prevent use of groundwater on important crops, by region

Results of these additional questions were combined into one response that summarizes areas without usable groundwater, due to either poor groundwater quality or lack of groundwater supply. Due to a lack of information these data are qualitative and based upon observations and the experience of URS staff. The results are summarized on Table 6.

A qualitative assessment was made of public water agencies without usable groundwater. In general, public water agencies along the eastern edge of the San Joaquin Valley do not have available groundwater resources due to low yield formations while public water agencies along the northwestern edge of the San Joaquin Valley do not have usable groundwater due to either high boron or high salinity.

The total area without usable groundwater was calculated by estimating the percentage of each public water agency without usable groundwater and the acreage of each public water agency, provided by DWR. Crop types were provided for each public water agency without usable groundwater. As summarized on Table 6, the estimated area without usable groundwater ranges from approximately 735 acres in Subarea 16 to 228,000 acres in Subarea 15.

Table 2: Maximum Monthly Pumping Rate Estimates (Question #1)
Delta Risk Management Strategy
Analysis of Agricultural Use of Groundwater

C2VSIM Subarea	Estimate from Public Water Agency Questionnaire Responses		Estimate from DWR Groundwater Elevation Data				
			Maximum Annual Change in Storage During Drought: 1992/91-1987/86 [2]			Estimated Maximum Monthly Pumping Rate [4] (acre-ft/month)	
	Number of Questionnaire Responses Received from Public Water Agencies	Estimated Maximum Monthly Pumping Rate [1] (acre-ft/month)	Calculated in GIS (acre-ft/year)	Portion of Subarea Included in GIS Calculation (percentage)	Proportioned Over Entire Subarea [3] (acre-ft/year)	20%	25%
10 [5]	8	21,395	43,430	64	67,961	13,592	16,990
13	2	NA [9]	821,668	73	1,124,929	224,986	281,232
14	1	123,261	NA [10]	NA [10]	NA [10]	NA [10]	NA [10]
15	4	12,860	620,402	39	1,604,597	320,919	401,149
16 [6]	1	NA [9]	123,235	92	134,054	26,811	33,513
17 [7]	0	NA [9]	338,020	89	380,750	76,150	95,187
18	2	NA [9]	845,910	56	1,519,609	303,922	379,902
19 [8]	5	31,633	179,586	12	1,475,512	295,102	368,878
20	2	329	194,117	12	1,571,974	314,395	392,994
21 [8]	4	414,506	318,920	17	1,927,031	385,406	481,758

Notes:
1. Based on reported number of currently operational wells and average pumping rate.
2. Based on change in 1987-1992 drought period groundwater storage between 1987 and 1986 (base year) and 1992 and 1991 (maximum pumping). Storage calculations are based on unconfined water elevation data provided by DWR. The calculation assumes that the change in storage is due to pumping only. Neither natural groundwater inflow and outflow nor aquifer recharge are taken into account.
3. Assumes that storage and pumping estimates for portion of Subarea with groundwater elevation data are consistent over entire Subarea. Also assumes that entire Subarea has sufficient groundwater supply.
4. Maximum monthly pumping estimated to be between 20% and 25% of annual pumping.
5. West Stanislaus ID overlaps subareas 9 and 10. Subarea 9 is not within the study area. Responses are counted for Subarea 10.
6. Subarea 16 is not significantly dependant on Delta-Export water.
7. Subarea 17 is primarily dependant on Friant Kern Contractors.
8. Wheeler Ridge-Maricopa WSD overlaps subareas 19 and 21. Responses are counted for each subarea.
9. Questionnaire data were not provided by public water agencies within this subarea.
10. Limited unconfined water available in Subarea 14 (Westlands W.D.) and therefore, storage is not estimated.

Table 3: Potential to Increase Monthly Pumping (Question #2)

Delta Risk Management Strategy

Analysis of Agricultural Use of Groundwater

C2VSIM Subarea	Install New Wells with Pumps [1]													
	Theoretical Ability to Install New Wells with Pumps [2]			Scaling Factor [4]	Practical Ability to Install New Wells with Pumps			Average New Well Pumping Rate [5] (per well)				Average Monthly Pumping Rate [6] (AF/month)		
	6 months [3]	1 year [3]	2 years [3]	percent	6 months	1 year	2 years	gpm	cfs	AF/day	AF/month	6 months	1 year	2 years
Shallow Wells (East Side of San Joaquin Valley, approximately 500 to 700 feet deep)														
13	24	48	96	65	16	31	62	2,250	5	10	305	4,758	9,515	19,031
16	24	48	96	65	16	31	62	2,250	5	10	305	4,758	9,515	19,031
17	24	48	96	65	16	31	62	2,250	5	10	305	4,758	9,515	19,031
18	24	48	96	65	16	31	62	2,250	5	10	305	4,758	9,515	19,031
20	24	48	96	65	16	31	62	2,250	5	10	305	4,758	9,515	19,031
Deep Wells (West Side of San Joaquin Valley, approximately 1,200 to 1,500 feet deep)														
10	12	24	48	65	8	16	31	2,250	5	10	305	2,379	4,758	9,515
14	12	24	48	65	8	16	31	2,250	5	10	305	2,379	4,758	9,515
15	12	24	48	65	8	16	31	2,250	5	10	305	2,379	4,758	9,515
19	12	24	48	65	8	16	31	2,250	5	10	305	2,379	4,758	9,515
21	12	24	48	65	8	16	31	2,250	5	10	305	2,379	4,758	9,515
Total	**180**	**360**	**720**	**--**	**120**	**235**	**465**	**2,250**	**5**	**10**	**305**	**35,683**	**71,365**	**142,731**

Notes:

1. These calculations assume that the potential to increase monthly pumping is solely dependant on the ability to install new wells with pumps. Based on information from drilling and pump companies, rehabilitating non-functional wells is not practical. This assumes that new wells are evenly distributed throughout Subareas.
2. Availability of pumps may be more of a limiting factor than drill rigs. Based on information from WDC Exploration and Wells in Woodland, CA and Layne Christensen Company in Fontana, CA, it takes approximately four weeks to drill a deep (1,200 to 1,500 ft) well and approximately two weeks to drill a shallow (~500 to 700 ft) well. Based on information from West Side Pump Co. in San Joaquin, CA and Calwest Rain, Inc. in Kerman, CA, it will take approximately six to nine months to build, install and complete a shallow well with a pump and approximately nine to twelve months to do the same for a deep well due to limitations to build the pumps.
3. Based upon theoretical maximum capability data provided by well drillers with consideration for practical efficiency or longer term sustainable capabilities.
4. Assumes that well installation efficiency is 65% due to unpredictable equipment failure, pump, driver and power availability and scheduling problems.
5. According to Layne Christensen Company, typical agricultural production rate for a new well ranges from 1,500 to 3,000 gpm. Average = 2,250 gpm.
6. Monthly data cannot be extrapolated to annual scale because pumps cannot operate continuously.

Table 4: Estimated Cost to Install New Wells (Question #3)
Delta Risk Management Strategy
Analysis of Agricultural Use of Groundwater

C2VSIM Subarea	Practical Ability to Install New Wells with Pumps [1]			Estimated Cost to Install New Wells with Pumps [2]															
				WDC Exploration and Wells [3]				Layne Christensen Company [4]				Calwest Rain, Inc. [5]				Average			
				Cost per Well	Total Cost			Cost per Well	Total Cost			Cost per Well	Total Cost			Cost per Well	Total Cost		
	6 months	1 year	2 years		6 months	1 year	2 years		6 months	1 year	2 years		6 months	1 year	2 years		6 months	1 year	2 years
Shallow Wells (East Side of San Joaquin Valley, approximately 500 to 700 feet deep)																			
13	16	31	62	$315,000	$5,040,000	$9,765,000	$19,530,000	$300,000	$4,800,000	$9,300,000	$18,600,000	$320,000	$5,120,000	$9,920,000	$19,840,000	$311,667	$4,986,667	$9,661,667	$19,323,333
16	16	31	62	$315,000	$5,040,000	$9,765,000	$19,530,000	$300,000	$4,800,000	$9,300,000	$18,600,000	$320,000	$5,120,000	$9,920,000	$19,840,000	$311,667	$4,986,667	$9,661,667	$19,323,333
17	16	31	62	$315,000	$5,040,000	$9,765,000	$19,530,000	$300,000	$4,800,000	$9,300,000	$18,600,000	$320,000	$5,120,000	$9,920,000	$19,840,000	$311,667	$4,986,667	$9,661,667	$19,323,333
18	16	31	62	$315,000	$5,040,000	$9,765,000	$19,530,000	$300,000	$4,800,000	$9,300,000	$18,600,000	$320,000	$5,120,000	$9,920,000	$19,840,000	$311,667	$4,986,667	$9,661,667	$19,323,333
20	16	31	62	$315,000	$5,040,000	$9,765,000	$19,530,000	$300,000	$4,800,000	$9,300,000	$18,600,000	$320,000	$5,120,000	$9,920,000	$19,840,000	$311,667	$4,986,667	$9,661,667	$19,323,333
Deep Wells (West Side of San Joaquin Valley, approximately 1,200 to 1,500 feet deep)																			
10	8	16	31	$900,000	$7,200,000	$14,400,000	$27,900,000	$765,000	$6,120,000	$12,240,000	$23,715,000	$600,000	$4,800,000	$9,600,000	$18,600,000	$755,000	$6,040,000	$12,080,000	$23,405,000
14	8	16	31	$900,000	$7,200,000	$14,400,000	$27,900,000	$765,000	$6,120,000	$12,240,000	$23,715,000	$600,000	$4,800,000	$9,600,000	$18,600,000	$755,000	$6,040,000	$12,080,000	$23,405,000
15	8	16	31	$900,000	$7,200,000	$14,400,000	$27,900,000	$765,000	$6,120,000	$12,240,000	$23,715,000	$600,000	$4,800,000	$9,600,000	$18,600,000	$755,000	$6,040,000	$12,080,000	$23,405,000
19	8	16	31	$900,000	$7,200,000	$14,400,000	$27,900,000	$765,000	$6,120,000	$12,240,000	$23,715,000	$600,000	$4,800,000	$9,600,000	$18,600,000	$755,000	$6,040,000	$12,080,000	$23,405,000
21	8	16	31	$900,000	$7,200,000	$14,400,000	$27,900,000	$765,000	$6,120,000	$12,240,000	$23,715,000	$600,000	$4,800,000	$9,600,000	$18,600,000	$755,000	$6,040,000	$12,080,000	$23,405,000
Total	**120**	**235**	**465**	**--**	**$61,200,000**	**$120,825,000**	**$237,150,000**	**--**	**$54,600,000**	**$107,700,000**	**$211,575,000**	**--**	**$49,600,000**	**$97,600,000**	**$192,200,000**	**--**	**$55,133,333**	**$108,708,333**	**$213,641,667**

Notes:
1. From Question #2.
2. Estimated costs were provided by three companies: WDC Exploration and Wells, Woodland, CA; Layne Christensen Company, Fontana, CA; and Calwest Rain, Inc. of Kerman, CA.
Estimated costs include drilling, pump materials, and pump installation.
3. WDC Exploration and Wells estimate: shallow well ~ $425/foot and $60,000 for pump, assume 600 ft well; deep well ~ $900,000 (lump sum estimate).
4. Layne Christensen estimate: shallow well ~ $400/foot and $60,000 for pump, assume 600 ft well; deep well ~ $500/foot and $90,000 for pump, assume 1,350 ft well.
5. Calwest Rain, Inc. estimate: shallow well ~ $200,000 for well and $120,000 for pump; deep well ~ $400,000 for well, $200,000 for pump.

Table 5: Change in Average Pumping Cost Due to Pumping Increase (Question #4)
Delta Risk Management Strategy
Analysis of Agricultural Use of Groundwater

C2VSIM Subarea	Average Groundwater Elevation [1,2] (ft above mean sea level)		Average Groundwater Elevation Change [2,3] (feet)	Approximate Groundwater Volume Change [4]			Incremental Pumping Cost Assuming Overall Plant Efficiency of 65% [6] ($/AF/ft)	Change in Average Pumping Cost [7]
				Calculated in GIS (AF)	Portion of Subarea Included in Calculation	Proportioned Over Entire Subarea [5]		
	1991	1992	1992-1991	1992-1991	(percentage)	AF		
10	89	86	-3	-201,900	65	-310,680	$0.292	$312,337
13	111	107	-4	-484,124	78	-624,094	$0.292	$770,924
14 [8]	-32	-62	-30	-600,000	100	-600,000	$0.292	$5,256,000
15	134	125	-8	-481,496	42	-1,158,940	$0.292	$2,642,735
16	235	233	-2	-110,349	92	-119,559	$0.292	$82,946
17	263	264	-2	-88,565	89	-99,500	$0.292	$47,019
18	233	240	-4	-322,944	59	-549,552	$0.292	$595,587
19	231	229	-5	-74,554	12	-597,785	$0.292	$959,327
20	189	195	-13	-104,557	13	-779,526	$0.292	$2,900,308
21	215	213	-14	-216,248	18	-1,200,909	$0.292	$4,833,186

Notes:

1. Annual groundwater elevation data was obtained from DWR. Data was collected from the unconfined aquifer in the spring of each year and geographic coverages vary slightly by year.
2. Average groundwater elevation and average groundwater elevation change were calculated in GIS.
3. Differences between elevation change and annual elevation calculations are due to slight variations in GIS data coverage and data resolution.
4. With the exception of Subarea #14, groundwater volume change was calculated in GIS based on groundwater elevation change, public water agency area, and specific yield. Public water agency area was obtained from DWR. Specific yield data was obtained from DWR's preliminary C2VSIM model.
5. Assumes that storage and pumping estimates for portion of Subarea with groundwater elevation data are consistent over entire Subarea. Also assumes that entire Subarea has sufficient groundwater supply.
6. 65% represents a reasonable estimate of Overall Plant Efficiency. Incremental pumping cost calculations are summarized in a separate spreadsheet.
7. Change in average cost is based on groundwater elevation change, groundwater volume change, and incremental pumping cost. Calculation assumes that pumping following a catastrophic levee event will approximate pumping during the peak drought year of 1991-1992.
8. Average groundwater elevation and pumping data is for the confined aquifer. Data is from Deep Groundwater Conditions Report, December 2005, Westlands Water District, Report Date March 2006. Groundwater volume change is represented by pumping volume (600,000 AF) between 1991 and 1992.

Table 6
Areas Without Usable Groundwater[1] (Additional Questions 1 and 2)
Delta Risk Management Strategy
Analysis of Agricultural Use of Groundwater

Public Water Agency	Subarea	Public Water Agency Area [2] (acres)	Percentage of Area Without Usable Groundwater	Total Area Without Usable Groundwater (acres)	Crop Type	Notes
Subarea 10						
Banta Carbona ID	9, 10	16,867	100% (see note)	6,747	75% row crop. Balance trees.	Approximately 40% of agency lies within Subarea 10, 60% lies within Subarea 9 (outside of study area). Have SJR Water Rights.
Centinella	10	900	100%	900	retired	Centinella WD was purchased by Westlands WD and retired. Area was not provided by DWR and is approximated.
Del Puerto WD	10	56,212	95%	53,401	15% Orchard. Balance row crop.	
Lansdale WD	10	754	100%	754	NA	Agency is inactive
Oak Flat WD	10	4,775	100%	4,775	almonds	
Santa Nella County WD	10	2,570	100%	2,570	urban	no ag useage
Total - Subarea 10	--	--	--	**69,146**	--	
Subarea 13						
Chowchilla WD	13	85,442	0%	0	pistachios/ almonds	All lands have useable groundwater
Madera ID	13	125,927	8%	10,000	pistachios/ almonds	Approximately 10,000 acres w/o usable gw
Madera WD	13	3,719	100%	3,719	urban	No ag useage
Root Creek WD	13	9,284	50%	4,642	citrus/ pistachios	Have "Holding Contracts". May not be affected.
Total - Subarea 13	--	--	--	**18,361**	--	

Table 6
Areas Without Usable Groundwater[1] (Additional Questions 1 and 2)
Delta Risk Management Strategy
Analysis of Agricultural Use of Groundwater

Public Water Agency	Subarea	Public Water Agency Area [2] (acres)	Percentage of Area Without Usable Groundwater	Total Area Without Usable Groundwater (acres)	Crop Type	Notes
Subarea 15						
Angiola WD	15	36,184	--	--	row crop	Overlaps Tulare Lake Basin W.S.D.
Dudley Ridge WD	15	38,265	100%	38,265	almonds / pistachios	
Melga WD	15	73,552	--	--	row crop	Ooverlaps Tulare Lake Basin W.S.D.
Tulare Lake Basin W.S.D.	15	190,019	100%	190,019	row crop	Includes Angiola WD and Melga WD
Total - Subarea 15	**--**	**--**	**--**	**228,284**	--	
Subarea 16						
International WD	16	735	100%	735	citrus	
Total - Subarea 16	**--**	**--**	**--**	**735**	--	
Subarea 17						
Hills Valley ID	17	4,327	100%	4,327	citrus	
Orange Cove ID	17	28,717	100%	28,717	citrus	
Tri-Valley WD	17	2,857	100%	2,857	citrus	
Total - Subarea 17	**--**	**--**	**--**	**35,901**	--	
Subarea 18						
Stone Corral ID	18	6,873	100%	6,873	citrus	
Tea Pot Dome WD	18	3,576	100%	3,576	citrus	
Terra Bella ID	18	13,859	50%	6,930	citrus	Approximately half of the agency is w/o usable groundwater
Vandalia ID	18	1,460	100%	1,460	citrus	
Total - Subarea 18	**--**	**--**	**--**	**18,838**	--	

Table 6
Areas Without Usable Groundwater[1] (Additional Questions 1 and 2)
Delta Risk Management Strategy
Analysis of Agricultural Use of Groundwater

Public Water Agency	Subarea	Public Water Agency Area [2] (acres)	Percentage of Area Without Usable Groundwater	Total Area Without Usable Groundwater (acres)	Crop Type	Notes
Subarea 19						
Berrenda Mesa WD	19	55,971	50%	27,986	almonds / pistachios	Approximately half of the agency is w/o usable groundwater
Devil's Den WD	19	8,812	100%	8,812	almonds / pistachios	
Green Valley WD	19	2,978	100%	2,978	almonds / pistachios	
Total - Subarea 19	--	--	--	**39,776**	--	
Subarea 20						
West Kern WD	21	202,733	7%	15,000	orchard	Approximately 15,000 acres w/o usable groundwater
Total - Subarea 20	--	--	--	**15,000**	--	
Outside of Study Region						

Table 6
Areas Without Usable Groundwater[1] (Additional Questions 1 and 2)
Delta Risk Management Strategy
Analysis of Agricultural Use of Groundwater

Public Water Agency	Subarea	Public Water Agency Area [2] (acres)	Percentage of Area Without Usable Groundwater	Total Area Without Usable Groundwater (acres)	Crop Type	Notes
Plain View WD	9	6,981	100%	6,981	row crop	
West Side ID	9	6,525	100%	6,525	row crop	
Tehachapi-Cummings CWD	NA	249,267	100%	249,267	5% pasture	Outside of subareas. Balance of land is cattle grazing.

Table 7
Estimated Costs of New Wells

	Estimated Drilling Cost			Estimated Pump Cost	Total Estimated Cost
	per foot	depth (ft)	total		
WDC					
shallow	$425	600	$255,000	$60,000	**$315,000**
deep	lump sum estimate (1,350 ft well)				**$900,000**
Layne					
shallow	$400	600	$240,000	$60,000	**$300,000**
deep	$500	1,350	$675,000	$90,000	**$765,000**
Calwest					
shallow	--	600	$200,000	$120,000	**$320,000**
deep	--	1,350	$400,000	$200,000	**$600,000**

- **South Of Delta Farm Income Loss Model**

The SOD Farm Income Loss Model estimates the change in SOD farm income relative to a baseline condition for a given temporary reduction in CVP and SWP project water deliveries. The model assumes farmers have available in the short-run two production responses to reduced project water deliveries: (1) they can substitute groundwater for project water to the extent permitted by pumping capacity; and (2) they can reduce crop production to balance water demands with available water supply. The model assumes farmers will select the response combination that minimizes the loss of farm income relative to the baseline condition.

- **Objective Function:**

$$\max_{x_j} \sum_j \left(\left[(1-\theta_{e,j})R_j - (1-\Gamma_{e,j})C_j\right](xbase_j - x_j)\right) - \sum_{i \ge e} P_i G1_i - \sum_{i \ge e} (P_i + W) G2_i$$

where,
e = the first month in which project deliveries are reduced
i = the index of calendar months
j = the index of crop types
x_j = acreage of crop j removed from production
$xbase_j$ = baseline acreage of crop j
R_j = baseline revenue per acre for crop j
C_j = baseline variable production cost per acre for crop j
$\theta_{e,j}$ = percent of annual revenue from crop j already realized by month e.
$\Gamma_{e,j}$ = percent of variable production cost already incurred by month e.
P_i = the variable cost of pumping additional groundwater in month i
W = the annualized per acre-foot cost of well development
$G1_i$ = the amount of additional groundwater from existing capacity pumped in month i
$G2_i$ = the amount of additional groundwater from new capacity pumped in month i

Constraints:

Crop Fallowing Constraint

$$0 \le x_j \le xbase_j$$

Monthly Pumping Constraints

$$0 \le G1_i \le G1\max_i$$

$$0 \le G2_i \le G2\max_i$$

where $G1max_i$ and $G2max_i$ are the maximum increases in monthly groundwater pumping from existing and new capacity in month i.

Water Balance Constraint

$$D_i + G1_i + G2_i + S_{i-1} - \sum_j I_{i,j}(xbase_j - x_j) \ge 0$$

where D_i is water deliveries from baseline groundwater pumping, local surface water, and curtailed project water deliveries in month i; S_{i-1} is the amount of stored surface water; and $I_{i,j}$ is crop j's applied water requirement in month i.

- **Stored Surface Water:**

For all i ≥ e, farmers can carryover unused surface water for delivery in subsequent months. The amount of stored surface water in month i is

$$S_i = D_i + S_{i-1} - \sum_j I_{i,j}\left(xbase_j - x_j\right)$$

This formulation assumes farmers use available surface water prior to pumping additional groundwater.

Additional Groundwater Pumping:

Farmers can increase groundwater pumping from existing capacity up to the monthly maximum. Additional groundwater pumping is a function of fallowed crop acreage (x_j):

$$G1_i + G2_i = \sum_j I_{i,j}\left(xbase_j - x_j\right) - D_i - S_{i-1}$$

Cost of Additional Groundwater Pumping:

The variable cost of additional groundwater pumping is a function of the amount of drawdown. The relationship between volume pumped and drawdown for the eleven model regions was estimated by URS. The incremental cost per acre-foot per foot of drawdown was also estimated by URS. The cost of groundwater pumping at the baseline level is taken from the CVPM data file. The equation governing the per acre-foot cost of additional groundwater from existing capacity is:

$$P_i = P_{i-1} + \left(G1_i + G2_i\right)\lambda\pi$$

where λ is the change in pumping lift per thousand AF of additional pumping and π is the incremental cost of pumping in dollars per AF per foot of lift, as estimated by URS. P_{e-1} is set to the baseline pumping cost.

Pumping from new wells also includes a capital charge, W, reflecting the per acre-foot cost of well development.

Appendix E
Urban Water Users

For each major urban agency likely to be affected by levee failures in the Delta, Table E-1 provides population estimates, end-user demand, and the approach to modeling shortages taken in this analysis.

Table E-1
Population and End-User Demand by Analyzed Agency

Agency	Population Estimates		End-user Demand (AF)		Shortage Approach
	2005	2030	2005	2030	
Alameda County WD	324,000	405,900	56,212	62,196	Modeled
Antelope Valley-East Kern	313,500	650,400	82,730	230,400	Modeled
Central Coast Water Authority	409,000	618,200	56,723	*	0
Contra Costa WD	507,800	649,300	143,750	222,300	Modeled
Coachella Valley	314,300	490,600	227,645	347,800	0
EBMUD	1,338,000	1,598,000	248,862	260,072	Modeled
Kern County Water Agency	326,000	458,000	35,700	52,785	0
Mojave WA	358,800	700,000	112,200	122,000	0
MWDSC	18,233,800	22,053,200	3,748,000	4,719,400	Modeled
San Mateo Co	698,600	806,600	101,518	113,255	Assumed
San Bernadino Valley Municipal WD	661,700	1,097,700	232,732	280,043	0
SCVWD	1,750,000	2,267,100	377,600	448,200	Modeled
San Francisco WD	798,000	871,000	103,580	104,700	Assumed
Zone 7	196,000	264,000	44,300	69,300	Modeled
Total	26,229,500	32,930,000	5,571,552	7,032,451	
Total Affected	27,221,900	33,818,100			
% of Total	96%	97%			

* Does not include San Luis Obispo Forecast not provided.

Sources: Urban Water Management Plans as cited below, plus the following:

Casitas Municipal Water District 2005; Central Coast Water Authority 2005; Coachella Valley Water District 2005; Crestline-Lake Arrowhead Water Agency 2005; Desert Water Agency 2005; East Bay Municipal Water District (EBMUD) 2005; Kern County Water Agency 2005; Mojave Water Agency 2005; Palmdale Water District 2005; San Bernardino Valley Municipal Water District 2005; San Francisco Public Utilities Commission (SFPUC) 2005; San Gabriel Valley Municipal Water District 2005; BAWSCA 2006; San Joaquin Council of Governments 2006.

Summary of Urban Water Management Plans Reviewed

Only two Central Valley Project (CVP) contractors receive the majority of the urban water supplies that would be affected by an interruption of supplies in the Delta; Contra Costa Water District (CCWD) and Santa Clara Valley Water District (SCVWD). SCVWD is also a State Water Project (SWP) contractor, so that agency's supply situation will be discussed within the SWP section of this memo. In the following discussion of each district's supply situation, Tables E-2 through E-11 provide key supply information.

Contra Costa Water District

CCWD's major water source is its diversions from the Delta. It has a contract for 195,000 AF/year from the CVP. CCWD has additional water rights at Mallard Slough. When Mallard Slough supplies are used, CVP diversions are reduced by an equivalent amount. Industries within CCWD's service territory have additional diversion rights. These are not totaled, but are more than 45,000 af/y. However, these diversion rights are not reliable because of variable water quality. The City of Antioch also has diversion rights, but because of poor quality obtains water from CCWD.

Existing CCWD wells in the vicinity of the Bollman Water Treatment Plant (Mallard Well Fields) can provide approximately 1,000 af/y but are limited by the threat of contamination from adjacent industrial areas and physical factors such as air entrapment. The Diablo Water District is currently constructing a groundwater blending facility that will provide approximately 500 af/y.

CCWD purchases surplus irrigation water to be used for M&I purposes in East Contra Costa County Irrigation District (ECCID)'s service area. Only a portion of ECCID is within the existing CCWD service area (estimated current demand of 5,700 af/y). The current ECCID agreement allows CCWD to purchase up to 8,200 af/y for service in the overlap area with ECCID. The agreement also includes an option for up to 4,000 af/yr of groundwater (by exchanges) when the CVP is in a shortage situation. This exchange water can be used anywhere within CCWD's service area. However, the ECCID water is also from the Delta, so it is not useful at times of Delta disruption.

Demand for approximately 1,600 af/y of recycled water has been identified, but service is still being extended. In addition, up to 8,600 af/y of tertiary treated recycled water will be supplied to the Delta Energy Center and the Los Medanos Energy Center and 20 acres of parks and landscaped areas for an additional 80 af/y. Additional recycled water projects will provide up to 1,650 af/y to areas in Pittsburg and Antioch. The recycled water would be for urban landscape and golf course irrigation uses.

Los Vaqueros Project provides 100,000 AF of offstream storage to improve water quality and to provide emergency storage. A large portion of the reservoir is reserved for emergency purposes. The reservoir provides up to 70,000 AF of emergency supply in wet years and up to 44,000 AF in dry years. This will vary by season of the year, and this is the maximum by year-type. In addition, there may be some potential for groundwater in the east of the county but this has not been explored.

During summer of 1991, as a response to drought emergency, approximately 400 AF of recycled water were distributed to Shell and Tosco (now Tesoro) refineries for cooling tower water. Groundwater resources in Contra Costa County are limited. Outside of the District only Byron-Bethany ID, ECCID, and the City of Brentwood have the ability to produce significant amounts of groundwater (approximately 5,000 acre feet annually each). The current ECCID agreement allows CCWD to purchase 4,000 af/y of groundwater via exchange when the CVP is in a shortage situation. The potential to increase groundwater pumping in East County would be explored in the event of an emergency.

Table E-2
CCWD Demand/Supply Balance (AF/year)

	Near Term	**2030**
Demand	143,750	222,300
Supplies CVP	 174,000	 195,000
Industrial Diversions	10,000	10,000
Mallard Slough	3,100	3,100
Antioch Diversions	6,700	6,700
ECCID Irrigation Water (Delta) Groundwater	 8,200 Up to 4,000	 8,200 4,000
Groundwater	3,000	3,000
Recycled Water	7,500	12,000
Dry year Transfers		Up to 21,500
Total Normal Year	210,100	251,600

Up to 3,200 AF of CCWD's CVP water will be diverted through the new Freeport intake to the Mokelumne-Los Vaqueros Pipeline intertie (scheduled to begin operating by 2007). The Freeport diversion will provide up to 112,000 af/yr to EBMUD in dry years (3 years in ten) when it is operational in 2010. (there appears to be a slight discrepancy in estimated in service dates).

The dry-year transfers are not yet identified or contracted. CCWD plans to contract for them as needs are identified. CCWD's analysis shows no need for dry year transfers in the immediate future. In 2010, 9000 af of dry-year transfers are shown to be needed only in later years of multi-year droughts (Contra Costa Water District 2005).

State Water Contractors

Two agencies take supplies from the North Bay Aqueduct. This diversion is fed by the strong flushing flows from the Sacramento River, so any interruption to that supply is likely to be extremely short. Because of this it is assumed that these agencies will have minimal impacts from a Delta disruption.

Santa Clara Valley Water District

SCVWD provides water to communities in Santa Clara County. These communities also obtain water from local sources and from the Hetch Hetchy system (through the SFPUC). Because the two distribution systems are interleaved, SCVWD has minor interconnections with Hetch Hetchy. However, because these are at the ends of the two distribution systems, the capacities are small.

SCVWD local surface storage capacity is 169 taf.

Table E-3
SCVWD Groundwater Basins

Groundwater Subbasin	Recharge Capacity	Maximum Annual Withdrawal
Santa Clara Valley	350 taf	200 taf
Coyote	23-33 taf	

Recharge to GWater Basins (taf/yr)				
	Average	Wet	Single Dry	Multiple Dry
Natural Recharge	53.6	87	33.6	50.4
Managed Recharge (local + imported)	116		49	92

Table E-4
SCVWD Demand/Supply Balance – Normal Year
(TAF)

Source	2010	2015	2020	2025	2030
SWP/CVP	197.4	197.4	197.4	197.4	197.4
Local Supplies	115.5	115.5	115.5	115.5	115.5
Recycled[1]	16.8	21.1	25	28.1	31.2
SFPUC[2]	64.6	68.9	71	72.6	73
New				12.2	31.1
Demand after conservation	358.4	371.6	381.1	401.5	423.9

[1]2004-2005 recycled water supplies = 11.3 TAF. Additions are identified in local UWMPs.
[2] Assumes SFPUC's Regional Water Supply Improvement Plan will be completed by 2015.

Table E-5
SCVWD Demand/Supply Balance –Single Dry Year
(TAF)

Source	2010	2015	2020	2025	2030
SWP/CVP*	111.8	111.8	111.8	111.8	111.8
Local Supplies	64.3	64.3	64.3	64.3	64.3
Recycled[1]	16.8	21.1	25	28.1	31.2
SFPUC[2]	48.5	51.1	52.2	53.4	54.7
Groundwater Reserves	141.3	147.6	152.1	168.1	186.1
Demand after conservation	358.4	371.6	381.1	401.5	423.9

* Includes Semitropic
[1]2004-2005 recycled water supplies = 11.3 TAF. Additions are identified in local UWMPs.
[2] Assumes SFPUC's Regional Water Supply Improvement Plan will be completed by 2015.

Table E-6
SCVWD Demand/Supply Balance –Multiple Dry Year
(TAF)

Source	2010	2015	2020	2025	2030
SWP/CVP*	168.8	168.8	168.8	168.8	168.8
Local Supplies	100.1	100.1	100.1	100.1	100.1
Recycled[1]	16.8	21.1	25	28.1	31.2
SFPUC[2]	51.7	54.5	55.7	57	58.4
Groundwater Reserves	45.2	51.4	55.7	71.8	76.0
New Supplies					13.7
Demand after conservation	358.4	371.6	381.1	401.5	423.9

* Includes Semitropic
[1]2004-2005 recycled water supplies = 11.3 TAF. Additions are identified in local UWMPs.
[2] Assumes SFPUC's Regional Water Supply Improvement Plan will be completed by 2015.

These projections are based on the following key assumptions:

- 28 taf additional conservation savings by 2020
- 20 taf of additional groundwater recharge capacity by 2010

Funding for these programs is not included in the CIP.

Long range possibilities to prepare for catastrophe include expanding well-fields on the east and west side of the valley. The preliminary cost estimate is $150 million, but the additional capacity is not stated. This option is still being investigated.

(Santa Clara Valley Water District 2005)

Alameda County Water District

ACWD has sufficient water supplies to meet demands in most years. To supplement supply in dry years it has local groundwater storage and 150,000 af capacity at Semitropic (currently 100,000 af in storage). It has two groundwater basins. One, the Niles Cone Groundwater Basin is recharged through local runoff from the Alameda Creek Watershed. Alameda Creek annual runoff at the USGS Alameda Creek near Niles stream gage (located near ACWD's recharge facilities) has varied from a recorded minimum of 650 af/y in 1960-1961, to a recorded maximum in 1982-1983 of 360,000 af/y. Typically, ACWD diverts only a small portion of the local runoff flowing in Alameda Creek.

The second, the Newark Aquifer is subject to saltwater intrusion particularly if inland groundwater levels remain at or near sea-level for a protracted period of time, or if inland groundwater levels drop further than five feet below sea level for any period of time. For this reason ACWD has been operating the basin to maintain a water level in the Newark Aquifer of at least five feet above sea level. ACWD has a desalination plant for water from this aquifer, and currently plans are to expand the capacity of the Newark desalination facility from 5 mgd to 10 mgd. The expansion is planned to be completed by 2009 but the increase in supply is not shown in its analysis. Given the high quality of the resulting water, the expanded Desal Project treated water will be blended with harder groundwater to improve the overall quality of the water delivered to customers and to the extent possible, extend the local supplies.

To date, recycled water is being used for environmental purposes, and not to offset potable water demand. ACWD forecasts 1600 af/y will be supplied by recycled water to offset potable uses by 2020. Without inclusion of the expanded desalination project, ACWD shows multiple dry year shortages of around 5 percent through 2030. Including the project expansion would remove these shortages. For single dry year shortages, ACWD's analysis projects shortages of around 15 percent. Inclusion of the desalination expansion would approximately halve this shortage, without taking into account the additional supply that might be obtained through the potential for blending the water from the desalination plant expansion.

The following table details the ACWD projections. Note that these do not include the doubling (at least) of the desalination project that is discussed in the text. In addition ACWD also has water distribution system pipeline interconnections with the City of Hayward and the City of Milpitas. These have been planned to be used during emergencies such as earthquakes. If appropriate, these interconnections could be used during a water supply emergency. As a SFPUC wholesale customer, ACWD may also receive emergency supply benefits from a recent intertie between the EBMUD system and the San Francisco Regional System, as well as the capacity to obtain additional water through its normal delivery points with SFPUC.

Groundwater modeling of the Niles Cone Groundwater Basin has indicated that the basin groundwater levels may be temporarily drawn down to below sea-level without causing long-term water quality impacts to the Basin. In a severe drought or water shortage emergency, as documented in ACWD's Integrated Resources Planning Study, ACWD may allow the Basin groundwater elevation to be temporarily drawn down as low as 5 feet below sea-level. The effect of this option also appears not to be included in the supply tables.

In 2004 ACWD completed an analysis of the potential water supply impacts of the loss of SWP supplies due to a catastrophic failure of Delta levees. The analysis evaluated ACWD’s ability to provide water to its customers considering no State Water Project or Semitropic/transfer water supply available. The analysis was based on (2005) distribution system demands, and storage conditions as of May 2004. The following rain year replenishment of local supplies assumed 2003 conditions for ground water and available diversions as well as 3,000 af of inflow to Del Valle with no additional emergency storage, and median SFPUC supply. The analysis showed that ACWD could continue to provide full water deliveries to its customers for over 12 months.

(Alameda County Water District 2005)

Table E-7
ACWD Projected Single Dry Year Demand/Supply Balance
(AF/year)

SUPPLY/DEMAND	Year				
	2010	2015	2020	2025	2030
SUPPLY COMPONENT					
Imported Supplies					
-State Water Project	1,700	1,800	1,800	1,900	1,900
- San Francisco Regional	11,700	13,700	14,100	12,700	13,100
Total Imported Supplies	**13,400**	**15,500**	**15,900**	**14,600**	**15,000**
Local Supplies					
- Groundwater Recharge	15,600	15,600	15,600	15,600	15,600
- Groundwater Storage	10,000	10,000	10,000	10,000	10,000
- Del Valle Release	100	100	100	100	100
- Desalination	5,600	5,600	5,600	5,600	5,600
- Recycled Water	0	0	1,600	1,600	1,600
Total Local Supplies	**31,300**	**31,300**	**32,900**	**32,900**	**32,900**
Banking/Transfers					
- Semitropic Banking	**13,500**	**13,500**	**13,500**	**13,500**	**13,500**
TOTAL SUPPLY	***58,200***	***60,300***	***62,300***	***61,000***	***61,400***
DEMAND COMPONENT					
- Distribution System Demand	59,500	61,400	63,200	63,700	64,300
- Estimated Conservation Savings	(700)	(1,500)	(2,200)	(2,200)	(2,200)
- Groundwater System Demands	10,500	10,500	10,500	10,500	10,500
TOTAL DEMAND	***69,300***	***70,400***	***71,500***	***72,000***	***72,600***
SUPPY & DEMAND COMPARISON					
- Supply Totals	58,200	60,300	62,300	61,000	61,400
- Demand Totals	69,300	70,400	71,500	72,000	72,600
- Difference	(11,100)	(10,100)	(9,200)	(11,000)	(11,200)
- Difference as % of Supply	-19%	-17%	-15%	-18%	-18%
- Difference as % of Demand	-16%	-14%	-13%	-15%	-15%

Notes:

1. Single Dry Year conditions are based on the projected supply availability under 1977 drought conditions.

2. Groundwater system demands include: (1) ARP groundwater production, (2) private groundwater pumping, and (3) saline groundwater outflows. Under dry year conditions ACWD's groundwater system demands may be reduced from Normal Year conditions due to a reduction in saline groundwater outflows as local groundwater elevations are temporarily lowered.

3. ACWD anticipates expanding the Newark Desalination Facility from 5 mgd to 10 mgd by the year 2010. Depending on groundwater conditions, the expanded desalination facility may provide up to 11,200 AF/Yr of supply.

4. As documented in ACWD's 2001-2005 UWMP, ACWD's long-term planning is based on conservation savings of 2,900 AF/Yr to be achieved by the year 2020. Of the 2,900 AF/Yr estimated savings, it is estimated that 700 AF/Yr of savings has already been achieved due to conservation program implementation between the years 2000 and 2005. This existing level of conservation savings (700 AF/Yr) is already accounted for in the demand projections. Therefore, this 2006-2010 Urban Water Management Plan assumes that the remaining balance of 2,200 AF/Yr savings (or 2,900 AF/Yr minus 700 AF/Yr) will be achieved by the year 2020.

Alameda Zone 7

The Livermore-Amador Valley overlies a Main Groundwater Basin (Main Basin) has an estimated storage capacity from 240,000 to 250,000 AF. Zone 7's typical operational plans call for seasonal storage of 15,000 to 20,000 AF of water within the groundwater basin and the maintenance of about 110,000 AF for drought storage. This preserves the approximately 240,000 AF of storage in the Main Basin for drought and emergency use - 110,000 AF for drought storage and 130,000 AF to be used only in case of extreme emergency. Long-term natural recharge is determined to be 13,400 af/y.

In addition, Zone 7 has the right to water runoff in the Del Valle area. The thirty year historic yield to Zone 7 from Lake Del Valle has been about 8,000 af/y. The future, long-term yield (2025) is calculated at 9,300 acre feet, because increased winter demands will allow more water to be used directly off the watershed rather than released to preserve storage for flood control needs. Due to limited storage capacity in Lake Del Valle, Zone 7 is not able to fully capture and maximize local runoff. Plans have been formulated to reclaim existing gravel quarries in the central portion of the Livermore-Amador Valley, between Livermore and Pleasanton, and grant these facilities to Zone 7 for use as groundwater recharge and water resource management facilities. This “Chain of Lakes” would provide the additional storage to allow Zone 7 to capture and use more local runoff. Zone 7 studies have shown that annual quantities of water available from local runoff will vary according to the hydrologic year but could add an additional 3,000 acre feet of water annually on average. Two quarry pits have already been transferred to Zone 7, and implementation of projects to protect water quality in Lake 1 have been commenced. Completion of the Chain of Lakes is scheduled for 2030.

Zone 7 also has storage outside the District, with Semitropic Water Storage Bank (65,000 af capacity, and 9,000 af/y minimum return) and with the Cawelo Water District (120,000 capacity with 10,000 af/y minimum pumpback.)

Table E-8
Zone 7 Minimum Water Supply Availability for a 6-Year Drought Between 2005–2012

SUPPLY SOURCE	Year 1 *	Year 2 *	Year 3 *	Year 4 *	Year 5 *	Year 6 *
State Water Project	66,280	8,060	69,420	16,930	16,930	29,210
SWP - Carryover	10,000	10,000	0	10,000	0	0
Semitropic Pumpback	0	8,680	8,150	9,780	9,780	11,200
Arroyo del Valle Watershed	380	290	4,290	480	4,560	6,720
Zone 7 Wells	17,000	33,400	17,000	23,230	29,150	13,300
BBID	2,000	2,000	2,000	2,000	2,000	2,000
TOTAL	95,660	62,430	100,860	62,420	62,420	62,430
TOTAL DEMAND (2012)	61,000	61,000	61,000	61,000	61,000	61,000

* Based upon six driest hydrologic years, 1987 - 1992.

Table E-9
Zone 7 Minimum Water Supply Availability for a 6-Year Drought
2023-2030

SUPPLY SOURCE	Year 1 *	Year 2 *	Year 3 *	Year 4 *	Year 5 *	Year 6 *
State Water Project	66,280	8,060	69,420	16,930	16,930	29,210
SWP - Carryover	10,000	10,000	0	10,000	0	0
Semitropic Pumpback	0	8,680	15,480	9,780	9,780	11,200
Cawelo Pumpback	0	10,000	0	10,000	10,000	10,000
Arroyo del Valle Watershed	380	290	4,290	480	4,560	6,720
Zone 7 Wells	17,000	30,730	17,000	20,560	26,480	10,630
BBID	2,000	2,000	2,000	2,000	2,000	2,000
TOTAL	95,660	69,760	108,190	69,750	69,750	69,760
TOTAL DEMAND (2030)	69,370	69,370	69,370	69,370	69,370	69,370

* Based upon six driest hydrologic years, 1987 - 1992.

Table E-10
Zone 7 Annual Demand 2005–2030
(af)

Table 16. Zone 7 Total Annual Demand, 2005-2030. Units in acre-feet.

ZONE 7 DEMANDS BY YEAR	2005	2006	2007	2008	2009	2010	2015	2020	2025	2030
TREATED, AF	43,650	45,120	46,190	47,270	48,290	49,370	57,240	59,110	60,960	61,120
UNTREATED, AF	3,900	4,300	4,410	4,540	4,720	8,250	8,250	8,250	8,250	8,250
TOTAL ANNUAL DEMAND	47,550	49,420	50,600	51,810	53,010	57,620	65,490	67,360	69,210	69,370

Existing wells can produce 2,760 af/month.

In the event that, as a result of a catastrophic occurrence, Zone 7 had no SBA capacity (approximately a 70-75% reduction in regional water supply), it plans to operate its wells and make use of water stored in Lake Del Valle and conveyed to the Zone 7 Del Valle Water Treatment Plant, to still have the ability to meet 75% of its estimated maximum day M&I demands. Zone 7 would be able to make full deliveries to its retail water supply agencies for most of the year. During this period, Zone 7 can meet M&I demands using only its groundwater resources. In the peak summer months, Zone 7 would reduce deliveries so that all of its retailers received the equivalent monthly cutbacks. Under this scenario, since Zone 7 lacks the necessary conveyance systems, some untreated water customers would not receive water.

(Alameda Zone 7 2005)

Antelope Valley East Kern Water District

Antelope Valley-East Kern Water District (AVEK) provides SWP water to a number of retail agencies and some customers directly. Most, if not all of these recipients have access to other water resources, but AVEK is not involved in these supplies. The majority of the SWP water supplied by AVEK (over 60 percent) is provided to Los Angeles County Waterworks Department (LACWD). The next largest identified customer is Edwards Air Force Base, and US Borax, each of which which receives approximately 3 percent of total SWP-supplied water. Therefore the LACWD supply situation is used as a proxy for the region as a whole.

The LACWD consists of three districts that pump their own groundwater. Reported groundwater levels are steady or rising. Safe yield is estimated to be 31,00 and 59,000 af. Recharge operations should extend this. However, USGS studies report declining groundwater levels in the eastern areas of the basin.

Table E-11
Antelope Valley East Kern Groundwater Pumping Levels

Groundwater Pumping Levels		
Current	Reduced	Maximum
27,000	13,500	33,000

Note:
Pumping capacity exists for an additional 30,000 af/yr, but does not plan to pump at this level.

Table E-12 provides supply projections under 3 scenarios. The ASR programs has been approved on a test basis, and will be monitored for its effect on the groundwater basin. The projections assume that this project will be completed successfully and then approved on a permanent basis in the future.

Tables E-13 through E-17 detail the expected supplies under different hydrologies. The planned new supplies include recycled water, which is required under new discharge requirements. The groundwater banking sources are currently being investigated, but have not yet been permitted. The expansion of an existing AVEK in-lieu program is one option being investigated.

Table E-12
Antelope Valley East Kern Groundwater Pumping Scenarios

(1) Reduced Groundwater Pumping

Study Area	2004	2010	2015	2020	2025	2030
Groundwater[a]	24,700	13,500	13,500	13,500	13,500	13,500
ASR	0	31,600	31,600	31,600	31,600	31,600
SWP[b]	41,500	84,700	87,100	89,400	91,800	91,800
Total	66,200	129,800	132,200	134,500	136,900	136,900

(2) Current Groundwater Pumping

Study Area						
Groundwater[a]	24,700	13,500	13,500	13,500	13,500	13,500
ASR	0	31,600	31,600	31,600	31,600	31,600
SWP[b]	41,500	84,700	87,100	89,400	91,800	91,800
Total	66,200	129,800	132,200	134,500	136,900	136,900

(3) Maximum Groundwater Pumping

Study Area						
Groundwater[a]	24,700	32,900	32,900	32,900	32,900	32,900
ASR	0	31,600	31,600	31,600	31,600	31,600
SWP[b]	41,500	84,700	87,100	89,400	91,800	91,800
Total	66,200	149,200	151,300	153,900	156,300	156,300

Table E-13
Antelope Valley East Kern Supplies
Average Water Year

	2010	2015	2020	2025	2030
Study Area					
Existing Water Supplies					
Groundwater	27,000	27,000	27,000	27,000	27,000
ASR	0	0	0	0	0
Imported Water	84,700	87,100	89,400	91,800	91,800
Total Existing Supply	111,700	114,100	116,400	118,800	118,800
Demand (w/out conservation)	86,000	105,100	125,300	146,200	169,100
Conservation	1,700	4,200	7,500	11,700	16,900
Demand (w/conservation)	**84,300**	**100,900**	**117,800**	**134,500**	**152,200**
Difference (supply minus demand)	27,400	13,200	(1,400)	(15,700)	(33,400)
Difference as Percent of Supply	25	12	(1)	(13)	(28)
Difference as Percent of Demand	33	13	(1)	(12)	(22)
Planned Water Supplies					
Groundwater Banking/New Supplies	0	0	2,000	11,600	23,100
Recycled Water	3,700	6,400	9,200	11,900	14,600
Total Planned Supply	3,700	6,400	11,200	23,500	37,700
Total Existing and Planned Supplies	**115,400**	**120,500**	**127,600**	**142,300**	**156,500**
Demand (w/out conservation)	86,000	105,100	125,300	146,200	169,100
Conservation	1,700	4,200	7,500	11,700	16,900
Demand (w/conservation)	**84,300**	**100,900**	**117,800**	**134,500**	**152,200**
Difference (supply minus demand)	31,100	19,600	9,800	7,800	4,300
Difference as Percent of Supply	27	16	8	5	3
Difference as Percent of Demand	37	19	8	6	3

Notes: All numbers rounded to nearest 100 AF.
(a) ASR supplies are available but will not be used in average years

Table E-14
Antelope Valley East Kern Supplies
Single Dry Year

	2010	2015	2020	2025	2030
Study Area					
Existing Water Supplies					
Groundwater	32,900	32,900	32,900	32,900	32,900
ASR	31,600	31,600	31,600	31,600	31,600
Imported Water	8,400	8,400	8,400	8,400	8,400
Total Existing Supply	72,900	72,900	72,900	72,900	72,900
Demand (w/out conservation)	85,900	105,100	125,200	146,200	169,100
Conservation	1,700	4,200	7,500	11,700	16,900
Demand (w/conservation)	**84,200**	**100,900**	**117,700**	**134,500**	**152,200**
Difference (supply minus demand)	(11,300)	(28,000)	(44,800)	(61,600)	(79,300)
Difference as Percent of Supply	(16)	(38)	(61)	(84)	(109)
Difference as Percent of Demand	(13)	(28)	(38)	(46)	(52)
Planned Water Supplies					
Groundwater Banking/New Supplies	12,300	23,700	36,800	50,000	65,000
Recycled Water	3,700	6,400	9,200	11,900	14,600
Total Planned Supply	16,000	30,100	46,000	61,900	79,600
Total Existing and Planned Supplies	**88,900**	**103,000**	**118,900**	**134,800**	**152,500**
Demand (w/out conservation)	85,900	105,100	125,200	146,200	169,100
Conservation	1,700	4,200	7,500	11,700	16,900
Demand (w/conservation)	**84,200**	**100,900**	**117,700**	**134,500**	**152,200**
Difference (supply minus demand)	4,700	2,100	1,200	300	300
Difference as Percent of Supply	5	2	1	0	0
Difference as Percent of Demand	6	2	1	0	0

Table E-15
Antelope Valley East Kern Supplies
Multiple Dry Years – Near Future

	2006	2007	2008	2009	2010
Study Area					
Existing Water Supplies					
Groundwater	32,900	32,900	32,900	32,900	32,900
ASR	0	0	0	0	0
Imported Water	21,400	21,500	21,500	21,400	21,500
Total Existing Supply	54,300	54,400	54,400	54,300	54,400
Demand (w/out conservation)	70,700	74,500	78,300	82,200	85,900
Conservation	200	500	900	1,300	1,700
Demand (w/conservation)	**70,500**	**74,000**	**77,400**	**80,900**	**84,200**
Difference (supply minus demand)	(16,200)	(19,600)	(23,000)	(26,600)	(29,800)
Difference as Percent of Supply	(30)	(36)	(42)	(49)	(55)
Difference as Percent of Demand	(23)	(26)	(30)	(33)	(35)
Planned Water Supplies					
Groundwater Banking/New Supplies	23,400	25,700	28,200	30,700	33,100
Recycled Water	1,000	1,700	2,400	3,150	3,700
Total Planned Supply	24,400	27,400	30,600	33,850	36,800
Total Existing and Planned Supplies	**78,700**	**81,800**	**85,000**	**88,150**	**91,200**
Demand (w/out conservation)	70,700	74,500	78,300	82,200	85,900
Conservation	200	500	900	1,300	1,700
Demand (w/conservation)	**70,500**	**74,000**	**77,400**	**80,900**	**84,200**
Difference (supply minus demand)	8,200	7,800	7,600	7,250	7,000
Difference as Percent of Supply	10	10	9	8	8
Difference as Percent of Demand	12	11	10	9	8

Table E-16
Antelope Valley East Kern Supplies
Multiple Dry Years (Distant Future)

	2026	2027	2028	2029	2030
Study Area					
Existing Water Supplies					
Groundwater	32,900	32,900	32,900	32,900	32,900
ASR	31,600	31,600	31,600	31,600	300
Imported Water	21,500	21,500	21,500	21,500	21,500
Total Existing Supply	86,000	86,000	86,000	86,000	54,700
Demand (w/out conservation)	150,700	155,300	159,900	164,500	169,100
Conservation	12,700	13,600	14,700	15,900	16,900
Demand (w/conservation)	**138,000**	**141,700**	**145,200**	**148,600**	**152,200**
Difference (supply minus demand)	(52,000)	(55,700)	(59,200)	(62,600)	(97,500)
Difference as Percent of Supply	(60)	(65)	(69)	(73)	(178)
Difference as Percent of Demand	(38)	(39)	(41)	(42)	(64)
Planned Water Supplies					
Groundwater Banking/New Supplies	40,300	53,900	46,000	48,800	83,200
Recycled Water	12,400	2,200	13,500	14,100	14,600
Total Planned Supply	52,700	56,100	59,500	62,900	97,800
Total Existing and Planned Supplies	**138,700**	**142,100**	**145,500**	**148,900**	**152,500**
Demand (w/out conservation)	150,700	155,300	159,900	164,500	169,100
Conservation	12,700	13,600	14,700	15,900	16,900
Demand (w/conservation)	**138,000**	**141,700**	**145,200**	**148,600**	**152,200**
Difference (supply minus demand)	700	400	300	300	300
Difference as Percent of Supply	1	0	0	0	0
Difference as Percent of Demand	1	0	0	0	0

(AVEK, 2005)

Castaic Lake

The sole source of local groundwater for urban water supply in the Valley is the Santa Clara River Valley East Sub-basin, which is comprised of two aquifer systems, the Alluvium and the Saugus Formation. The Alluvium generally underlies the Santa Clara River and its several tributaries, and the Saugus Formation underlies practically the entire Upper Santa Clara River area. Pumping from the Alluvial Aquifer is governed by local hydrologic conditions in the eastern Santa Clara River watershed. Pumping ranges between 30,000 and 40,000 af/y during normal and above-normal rainfall years, and reduced to between 30,000 and 35,000 af/y during locally dry years. Pumping from the Saugus Formation in a given year is tied directly to the availability of other water supplies, particularly from the SWP. During average year conditions within the SWP system, Saugus pumping ranges between 7,500 and 15,000 af/y. Planned dry-year pumping from the Saugus Formation ranges between 15,000 and 25,000 af/y during a drought year and can increase to between 21,000 and 25,000 af/y if SWP deliveries are reduced for two consecutive years and between 21,000 and 35,000 afy if SWP deliveries are reduced for three consecutive years. Such high pumping would be followed by periods of reduced (average-year) pumping, at rates between 7,500 and 15,000 af/y, to further enhance the effectiveness of natural recharge processes that would recover water levels and groundwater storage volumes after the higher pumping during dry years.

Table E-17
Groundwater Operating Plan for the Santa Clarita Valley

Aquifer	Groundwater Production (af)			
	Normal Years	Dry Year 1	Dry Year 2	Dry Year 3
Alluvium	30,000 to 40,000	30,000 to 35,000	30,000 to 35,000	30,000 to 35,000
Saugus	7,500 to 15,000	15,000 to 25,000	21,000 to 25,000	21,000 to 35,000
Total	**37,500 to 55,000**	**45,000 to 60,000**	**51,000 to 60,000**	**51,000 to 70,000**

In the Alluvium Aquifer, existing pumps operated by purveyor companies have a maximum capacity of 58,100 af/yr, with normal year production limited to 23,225 af/yr and dry year production to 19,095 af/yr. In the Saugus Aquifer, these numbers are 24,000, 5,955 and 16,372 af/yr, respectively. These numbers are based on currently active wells only; additional capacity to meet dry-year operating plan would be met by restoration of contaminated wells and new well construction. Treatment facilities for several of the impacted wells will be operational in 2006 and the production restoration (replacement) wells will be operational by 2010.

Castaic Lake has also developed a plan to invest in groundwater banking. Table E-18 shows the planned investment.

Table E-18
Future Reliability Enhancement Programs

Project Name	Year Available	Proposed Quantities (af)		
		Average/ Normal Year	Single Dry Year	Multiple Dry Years (1)
Rosedale-Rio Bravo Water Banking Program	2006	0	20,000	20,000
Additional Planned Banking Programs	2014	0	20,000	20,000

Notes:
(1) Supplies shown are maximum withdrawal capacity for each of four consecutive dry years.

As of the end of 2003, 50,870 af was in storage with Semitropic, and is recoverable through 2013. In 2005, CLWA and Rosedale-Rio Bravo executed a deposit agreement for the exclusive right to negotiate for groundwater banking in that facility, and CLWA approved an EIR in October 2005. CLWA anticipates that, upon completion of CEQA documentation this program will be operational by 2006. CLWA is assessing additional water banking opportunities, including programs with the Chino Basin Watermaster (with whom CLWA signed an MOU in 2003), Calleguas Municipal Water District, and San Gorgonio Pass Water Agency.

CLWA is also in the process of acquiring a permanent transfer of 11,000 af from Buena Vista-Rosedale. This is expected to be available in 2006. Currently, CLWA uses 800 afy of recycled water, and has been approved to use a total of 1,700 afy. This is expected to increase, as shown in Table E-19. Increases in recycled water will be driven by restrictions on discharge of wastewater.

Table E-19
Projected Potential Future Use of Recycled Water in Service Area

Type of Use	Projected Use (af)				
	2010	2015	2020	2025	2030
Landscape	1,600	3,300	8,000	12,700	17,400
Total	1,600	3,300	8,000	12,700	17,400

Tables E-20 and E-21 show projected supplies in normal years and under emergency conditions.

(Castaic Lake 2005)

Table E-20
Castaic Lake Projected Normal Year Supplies and Demands

Water Supply Sources	Supply (af)				
	2010	2015	2020	2025	2030
Existing Supplies					
Wholesale (Imported)	*67,600*	*69,500*	*71,400*	*73,300*	*73,300*
SWP Table A Supply (1)	67,600	69,500	71,400	73,300	73,300
Flexible Storage Account (CLWA) (2)	0	0	0	0	0
Flexible Storage Account (Ventura County) (2)	0	0	0	0	0
Local Supplies					
Groundwater	*46,000*	*46,000*	*46,000*	*46,000*	*46,000*
Alluvial Aquifer	35,000	35,000	35,000	35,000	35,000
Saugus Formation	11,000	11,000	11,000	11,000	11,000
Recycled Water	1,700	1,700	1,700	1,700	1,700
Total Existing Supplies	115,300	117,200	119,100	121,000	121,000
Existing Banking Programs					
Semitropic Water Bank (2)	0	0	0	0	0
Total Existing Banking Programs	0	0	0	0	0
Planned Supplies					
Local Supplies					
Groundwater	*0*	*0*	*0*	*0*	*0*
Restored wells (Saugus Formation) (2)	0	0	0	0	0
New Wells (Saugus Formation) (2)	0	0	0	0	0
Recycled Water (3)	0	1,600	6,300	11,000	15,700
Transfers					
Buena Vista-Rosedale (4)	11,000	11,000	11,000	11,000	11,000
Total Planned Supplies	11,000	12,600	17,300	22,000	26,700
Planned Banking Programs					
Rosedale-Rio Bravo (2)	0	0	0	0	0
Additional Planned Banking (2)	0	0	0	0	0
Total Planned Banking Programs	0	0	0	0	0
Total Existing and Planned Supplies and Banking	126,300	129,800	136,400	143,000	147,700
Total Estimated Demand (w/o conservation) (5)	100,050	109,400	117,150	128,400	138,300
Conservation (6)	(8,600)	(9,700)	(10,700)	(11,900)	(12,900)
Total Adjusted Demand	91,450	99,700	106,450	116,500	125,400

Table E-21
Castaic Lake Projected Supplies and Demands During 6-Month Disruption of Imported Supplies

	Supply / Demand (af)					
	2005	2010	2015	2020	2025	2030
Local Supplies						
Existing Supplies						
Groundwater						
Alluvial Aquifer (2)	17,500	17,500	17,500	17,500	17,500	17,500
Saugus Formation (3)	5,000	7,500	7,500	7,500	7,500	7,500
Recycled Water (4) (5)	190	600	640	640	640	640
Planned Supplies						
Groundwater (3)						
Restored wells (Saugus Formation)	0	5,000	5,000	5,000	5,000	5,000
New Wells (Saugus Formation)	0	0	0	5,000	5,000	5,000
Recycled Water (5)	0	0	600	2,360	4,130	5,890
Total Existing and Planned Local Supplies	22,690	30,600	31,240	38,000	39,770	41,530
SWP West Branch Storage Available						
Flexible Storage (at Castaic Lake)						
Existing (CLWA)	4,680	4,680	4,680	4,680	4,680	4,680
Existing (Ventura County) (6)	0	1,380	1,380	0	0	0
Emergency Storage						
Pyramid Lake (7)	4,370	4,370	4,370	4,370	4,370	4,370
Castaic Lake (8)	3,370	3,370	3,370	3,370	3,370	3,370
Total West Branch Storage	12,420	13,800	13,800	12,420	12,420	12,420
Total Local Supplies and West Branch Storage	35,110	44,400	45,040	50,420	52,190	53,950
Demands (9)						
Total Estimated Demand (w/o Conservation) (10)	44,700	50,000	54,700	58,600	64,200	69,100
Conservation (11)	(3,700)	(4,300)	(4,900)	(5,300)	(6,000)	(6,500)
Total Demand (w/ Conservation)	41,000	45,700	49,800	53,300	58,200	62,600
Additional Conservation Required	5,900	1,300	4,800	2,900	6,000	8,700
Additional Conservation as Percent of Demand (12)	16%	3%	10%	5%	10%	13%

Notes:

(1) Assumes complete disruption in SWP supplies and in deliveries through the California Aqueduct for six months.

(2) Pumping from the Alluvial Aquifer is assumed to be one-half of average/normal year supplies (see Table 6-2).

(3) Pumping from the Saugus Formation is assumed to be one-half of single dry year supplies (see Table 6-3).

(4) Existing recycled water supply is based on one-half of current actual use of about 500 af for 2005, projected demand of 1,600 af for 2010, and existing supply of 1,700 af from 2015 on, as adjusted for the reduction described in Footnote 5.

(5) Assumes 25 percent reduction in waste discharge, and therefore in recycled water availability, due to additional voluntary conservation.

(6) Initial term of the Ventura County entities' flexible storage account is ten years (from 2006 to 2015).

(7) CLWA's share of usable storage at Pyramid Lake, based on its 2.817 percent proportionate share of capital cost repayment of the reservoir. Usable storage is assumed to be 165,100 af (maximum operating storage of 169,900 af, less regulatory storage of 10,000 af for making peak summer deliveries and dead pool storage of 4,800 af).

(8) CLWA's share of usable storage at Castaic Lake, based on its 2.927 percent proportionate share of capital cost repayment of the reservoir. Usable storage is assumed to be 115,100 af (maximum operating storage of 323,700 af, less regulatory storage of 30,000 af for making peak summer deliveries, total SWP contractor flexible storage of 160,000 af, and dead pool storage of 18,600 af).

(9) Demands are assumed to be one-half of average/normal year demands (see Table 2-2).

(10) Demands are for uses within the existing CLWA service area. Demands for any annexations to the CLWA service area will be added if and when such annexations are approved. During a six-month outage, currently proposed annexations would have a demand for about 2,000 afy and, given supplies CLWA is in the process of acquiring, potential future annexations with demands up to an additional 3,500 afy

Central Coast Water Authority

The Central Coast Water Authority supplies supplemental water to communities in Santa Barbara and San Luis Obispo counties. The two major communities in this area are Santa Barbara and Santa Maria. Although Santa Maria has abundant groundwater, it is more reliant on SWP water because of discharge concerns arising from the high total dissolved solid and nitrogen levels in the groundwater basin. The Santa Maria UWMP is not yet available, but Central Coast Water Authority personnel believed that Santa Maria would likely be able to use groundwater if limited supplies of SWP water were available.

The City of Santa Barbara projects that current supplies will be sufficient to meet demands through 2030 with the exception of a repeat of the extreme drought that occurred in 1990. The SWP supplies will be used to maintain levels in Cachuma reservoir so as to avoid the worst effects of that drought. In addition, the city still has mothballed the desalination plant installed during the last drought.

Mojave Water Agency

The SWP water going to Mojave is used to recharge the aquifer. It is expected that any shortfall of SWP deliveries would be made up by increasing groundwater production. This is expected to meet demands through 2025. Additional recycled water projects are planned, but these are because of discharge constraints, and water supply results are of secondary importance.

Coachella Valley Water District

This District uses its allotment of SWP water to recharge groundwater basins. In future, the SWP water is projected to be approximately $1/8^{th}$ of total recharge to the basin.

San Bernardino Valley Municipal Water District

This agency requires that all of the purveyors to which it delivers water should use SWP supplies strictly as a supplementary water supply, and should maintain the ability to substitute other water supplies for the SWP deliveries. It is therefore likely that there would be no effect on this region. The City of San Bernardino's UWMP reports an analysis using multiple dry years corresponding to 1987-1991 hydrology, and shows that no shortages would be expected until after 2020. By the years 2021 through 2025, the estimated shortage would be less than 5 percent per year.

Metropolitan Water District of Southern California

MWDSC serves the area with the largest number of people who obtain water from the Delta. The agency serves water to a number of water agencies in six counties in Southern California. MWDSC has an extensive water storage program. It also obtains water from other sources, and its member agencies also obtain water from other sources. Tables E-22 through E-24 provide the projected demand supply balance.

Table E-22
MWDSC Single Dry Year Demand and Supply[1]

(Repeat of 1977 Hydrology)
(Acre-Feet)

	2010	2015	2020	2025	2030
Current Supplies					
In-Basin Storage	1,149,000	1,161,000	1,113,000	1,066,000	1,017,000
California Aqueduct [2]	777,000	777,000	777,000	777,000	777,000
Colorado River Aqueduct [3]	722,000	699,000	699,000	699,000	699,000
Supplies Under Development					
In-Basin Storage	78,000	103,000	103,000	103,000	103,000
California Aqueduct	330,000	259,000	350,000	350,000	350,000
Colorado River Aqueduct	95,000	460,000	400,000	400,000	400,000
Transfers to Other Agencies	0	(35,000)	(35,000)	(35,000)	(35,000)
Metropolitan Supply Capability	*3,151,000*	*3,424,000*	*3,407,000*	*3,360,000*	*3,311,000*
Metropolitan Supply Capability w/CRA Maximum of 1.25 MAF [4]	*3,151,000*	*3,356,000*	*3,309,000*	*3,252,000*	*3,203,000*
Firm Demands on Metropolitan [5,6]	*2,320,000*	*2,196,000*	*2,229,000*	*2,358,000*	*2,487,000*
Potential Reserve & Replenishment Supplies	**831,000**	**1,160,000**	**1,080,000**	**894,000**	**716,000**

[1] Represents supply capability for resource programs under listed year type

[2] California Aqueduct includes Central Valley transfers and storage program supplies conveyed by the aqueduct

[3] Colorado River Aqueduct includes water management program supplies conveyed by the aqueduct

[4] Maximum CRA deliveries limited to 1.25 MAF including SDCWA/IID Transfer supplies and Coachella and All-American Canals lining supplies.

[5] Based on SCAG 2004 RTP, SANDAG 2030 forecasts, projections of member agency existing and contracted active conservation and local supplies, remaining regional targets for active conservation, SDCWA/IID Transfer supplies and Coachella and All-American Canals lining supplies.

[6] Includes projected firm sales plus 70% of projected IAWP agricultural sales

Table E-23
MWDSC Multiple Dry Year Demand and Supply[1]

(Repeat of 1990-92 Hydrology)
(Acre-Feet)

	2010	2015	2020	2025	2030
Current Supplies					
In-Basin Storage	514,000	518,000	502,000	487,000	470,000
California Aqueduct [2]	912,000	912,000	912,000	912,000	912,000
Colorado River Aqueduct [3]	722,000	699,000	699,000	699,000	699,000
Supplies Under Development					
In-Basin Storage	78,000	103,000	103,000	103,000	103,000
California Aqueduct	330,000	215,000	299,000	299,000	299,000
Colorado River Aqueduct	95,000	460,000	400,000	400,000	400,000
Transfers to Other Agencies	0	(35,000)	(35,000)	(35,000)	(35,000)
Metropolitan Supply Capability	*2,651,000*	*2,872,000*	*2,880,000*	*2,865,000*	*2,848,000*
Metropolitan Supply Capability w/CRA Maximum of 1.25 MAF [4]	*2,651,000*	*2,804,000*	*2,782,000*	*2,757,000*	*2,740,000*
Firm Demands on Metropolitan [5,6]	*2,392,000*	*2,302,000*	*2,309,000*	*2,448,000*	*2,585,000*
Potential Reserve & Replenishment Supplies	**259,000**	**502,000**	**473,000**	**309,000**	**155,000**

[1] Represents supply capability for resource programs under listed year type

[2] California Aqueduct includes Central Valley transfers and storage program supplies conveyed by the aqueduct

[3] Colorado River Aqueduct includes water management program supplies conveyed by the aqueduct

[4] Maximum CRA deliveries limited to 1.25 MAF including SDCWA/IID Transfer supplies and Coachella and All-American Canals lining supplies

[5] Based on SCAG 2004 RTP, SANDAG 2030 forecasts, projections of member agency existing and contracted active conservation and local supplies, remaining regional targets for active conservation, SDCWA/IID Transfer supplies and Coachella and All-American Canals lining supplies

[6] Includes projected firm sales plus 70% of projected IAWP agricultural sales

Table E-24
MWDSC Average Year Demand and Supply[1]

(Average of 1922 – 2004 Hydrologies)
(Acre-Feet)

	2010	2015	2020	2025	2030
Current Supplies					
In-Basin Storage	0	0	0	0	0
California Aqueduct [2]	1,772,000	1,772,000	1,772,000	1,772,000	1,772,000
Colorado River Aqueduct [3]	711,000	678,000	677,000	677,000	677,000
Supplies Under Development					
In-Basin Storage	0	0	0	0	0
California Aqueduct	185,000	185,000	240,000	240,000	240,000
Colorado River Aqueduct	0	0	0	0	0
Transfers to Other Agencies	0	(35,000)	(35,000)	(35,000)	(35,000)
Metropolitan Supply Capability	*2,668,000*	*2,600,000*	*2,654,000*	*2,654,000*	*2,654,000*
Metropolitan Supply Capability w/CRA Maximum of 1.25 MAF [4]	*2,668,000*	*2,600,000*	*2,654,000*	*2,654,000*	*2,654,000*
Firm Demands on Metropolitan [5,6]	*2,036,000*	*1,947,000*	*1,983,000*	*2,110,000*	*2,246,000*
Potential Reserve & Replenishment Supplies	632,000	653,000	671,000	544,000	408,000

[1] Represents supply capability for resource programs under listed year type

[2] California Aqueduct includes Central Valley transfers and storage program supplies conveyed by the aqueduct

[3] Colorado River Aqueduct includes water management program supplies conveyed by the aqueduct

[4] Maximum CRA deliveries limited to 1.25 MAF including SDCWA/IID Transfer supplies and Coachella and All-American Canals lining supplies

[5] Based on SCAG 2004 RTP, SANDAG 2030 forecasts, projections of member agency existing and contracted active conservation and local supplies, remaining regional targets for active conservation, SDCWA/IID Transfer supplies and Coachella and All-American Canals lining supplies

[6] Includes projected firm sales plus 70% of projected IAWP agricultural sales

It should be noted that the firm demands on MWDSC are less than 45 percent of regional demands as shown in Table E-25. That is, over half of the region's supplies come from sources other than MWDSC. In addition, MWDSC obtains some of its supplies from the Colorado River, so the regional shortage in the event of Delta failure would be less than 50 percent. Because of supply constraints it is possible that regions within MWDSC's service territory may be higher or lower than that.

MWDSC has dedicated some of its locally-stored water to be emergency supplies that will not be tapped unless the surface water supply is interrupted. This originally was planned to provide reliability in the event of a failure of the California Aqueduct, but would also be available for a Delta failure.

Table E-25
MWDSC Share of Regional Demands

	2010	2030
Total Demands	5,493,000	6,39,5000
Conservation	865,000	1,188,000
Net Demands	4,628,000	5,207,000
Local Supplies[1]	2,393,000	2,770,000
Demands on MWDSC	2,235,000	2,437,000
Interruptible	199,000	191,000
Firm Demands on MWDSC	2,036,000	2,246,000
% of Regional Demands	44%	43%

[1] Local supplies include Los Angeles Department of Water and Power's imported supplies over the LA Aqueduct and San Diego County Water Authority's water transfer from Imperial ID.

MWDSC has dedicated some of its locally-stored water to be emergency supplies that will not be tapped unless the surface water supply is interrupted. This originally was planned to provide reliability in the event of a failure of the California Aqueduct, but would also be available for a Delta failure.
(Metropolitan 2005)

Urban Agency Survey

The following page provides an example of the survey form sent to selected urban water agencies. The questions asked were repeated for normal, dry and critically dry years. Then the same questions were asked for the four year-types for 2030 or similar "distant future" conditions. Persons responsible for filling out the form were contacted for additional information where necessary. The pages after the form example provide a copy of the letter sent with the form.

Agency Name ______________________________ **Person Responding**__________________ **Telephone**__________

UNITS TAF/Other If Other, please describe ___________________________

2006 or "Current Information

Demand		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	**Comments**
1	Total End-User Demand (not including to storage)													
2	Interruptible Demand													
Supply -- Wet Conditions														
3	Groundwater Storage													
	Stored volume													
	Maximum withdrawal rate													
	Surface storage													
	Stored volume													
	Inflow/Evaporation													
4	Other Sources													
	Recycled Water Sales													
	Local Groundwater Prod													
5	Other Supply Agreements													

Urban Agency Survey Letter

October 11, 2006

As you are aware, the Department of Water Resources (DWR) has recently undertaken a large effort to conduct a Delta Risk Management Strategy (DRMS) study to assess major risks to Delta levees from flood, seepage, subsidence and earthquakes. In addition to assessing risks to Delta, DRMS will evaluate the consequences of levee failures, including consequences to communities that rely on Delta assets or products, and develop recommendations to manage those risks. DRMS is an outgrowth of the risk management program element of CALFED Record of Decision of 2000. It is intended to accomplish risk management program goals and to provide a set of alternative risk reduction plans to be considered in subsequent decision/implementation phases. DRMS is jointly being conducted by DWR and the US Army of Corps of Engineers in conjunction with the California Department of Fish and Game. URS Corporation was selected as the consultant to perform the DRMS work and they have retained an excellent team, comprised of over 20 sub-consultants, to help them.

As part of the DRMS effort, the URS team (URS) is investigating what the urban agencies could do to respond to Delta export disruptions for a range of time periods, given current resources and planning. At this stage they do not want to investigate how your operations and plans could be changed to minimize risks from Delta failure; URS is trying to understand how future disruptions in the Delta could interact with existing facilities and plans. This is being called the “Current Trends” analysis, and so must rely on your existing planning.

To help URS understand your situation, I am requesting that you provide URS with some of your planning estimates. URS needs to understand how the situation will change with time, so they are requesting estimates of your situation in 2005 and 2030. Obviously the 2030 estimates will be subject to change, but I would appreciate your giving URS an understanding of your current planning for that period. This information should be consistent with the Urban Water Management Plans, to the extent possible. However, because we are looking at how the season of an event could change the consequences, we need to have monthly data if at all possible.

In addition, we are looking to understand how the consequences of a disruption might vary according to initial conditions – including such variables as the amount of water in local storage. Because of this, we are asking for information about your water supplies that may vary by year-type (wet, normal, dry and critically-dry). This request is based on the assumption that you will have this information as part of your normal supply modeling. If you do not have supply estimates by month or that vary by year-type, please provide URS with what you do use for planning purposes (annual estimates, or average year information, for example) and an explanation of the basis of your planning. It is expected that you will have this data on hand, and will not need to undertake further analysis. If this is not the case, please let URS know so that they can modify their requests to fit what you do have. It is not the intention that you undertake an extensive data collection or analysis project to supply these estimates.

It would also be most convenient if you could provide the estimates in electronic form – most useful would be on the Excel spreadsheets that will be emailed to you. As a result, although URS is providing you with written questions survey form, I expect that your answers will be entered into the Excel spreadsheet. Please note that there are two worksheets in the file – one for 2005 or “current” situation, and one for 2030 or as near to that date as your planning permits.

The data will be used to estimate the range of shortages that agencies might experience, given a range of initial conditions and disruption scenarios. This range of shortages will be used to drive a model that will develop part of an estimate of the costs of levee failures. The second stage of the DRMS project will use this "existing conditions" analysis as a comparison to evaluate cost-effectiveness of programs that may be proposed to mitigate the economic and environmental risks to California of Delta levee failures.

Please review the attached requests, and let URS know if you have any problems or concerns with providing us with these data. We would appreciate it if the completed spreadsheets could be emailed back to us by November 10. The URS contact for this information is Wendy Illingworth. Her phone number is 831 427 2163, and her e-mail address is wendy@econinsights.com. I appreciate your help in facilitating the response to this request. Full disclosure of accurate, current data on this topic will help to make the DRMS study an accurate guide to future Delta policy aimed at protecting critical assets located in the Delta. If you should have any questions, please do not hesitate to contact Ralph Svetich at (916) 651-7020 or myself at (916) 651-7017. Thank you, again for your help.

Sincerely,

David M. Mraz, Acting Chief
Delta-Suisun Marsh Office
Division of Flood Management

Economic Costs by Agency

Tables E-26 and E-27 provide the estimates of economic costs by agency, in 5 percent intervals for 2005 and 2030 conditions. When the shortage percentages were estimated under each scenario, the appropriate shortage cost was found by interpolating between the two closest estimates provided here.

Table E-26
2005 Urban Shortage Cost per Month,
$Millions 2005

Estimated Shortage %	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
Alameda County Water District	0	0.4	1.2	2.4	3.9	5.7	7.7	10.0	12.4	14.8	22.3	33.5	50.4	75.8	114.1	171.6	258.1	388.2	583.9	878.3	1,321.1
Antelope Valley East Kern	0	0.6	1.8	3.5	5.6	8.2	11.1	14.3	17.8	21.5	22.9	26.6	30.3	34.1	37.9	41.5	45.1	48.6	51.9	54.9	714.9
CCWD	0	1.5	4.6	9.0	14.5	21.1	28.4	36.4	44.0	51.9	55.9	66.4	76.8	87.2	97.6	107.9	118.2	128.3	138.3	148.2	1,896.6
EBMUD	0	2.2	6.5	12.8	20.7	30.0	40.6	52.3	64.6	76.7	82.1	96.4	110.7	125.0	139.1	153.1	166.9	180.4	193.5	206.1	5,343.5
MWDSC Los Angeles	0	6.6	17.7	33.1	52.6	76.0	102.9	133.3	166.8	203.2	322.6	512.3	813.5	1,291.8	2,051.3	3,257.4	5,172.4	8,213.4	3,042.2	20,709.9	32,885.6
MWDSC Orange	0	2.2	6.0	11.1	17.6	25.3	34.3	44.3	55.5	67.6	106.6	168.1	265.0	417.9	658.9	1,039.1	1,638.5	2,583.7	4,074.1	6,424.4	10,130.5
MWDSC Riverside	0	1.0	2.3	4.1	6.3	9.0	11.9	15.3	19.0	23.1	34.0	50.0	73.5	108.1	158.9	233.7	343.7	505.3	743.0	1,092.6	1,606.6
MWDSC San Bernardino	0	0.7	1.7	3.1	4.7	6.6	8.8	11.3	14.0	17.0	28.0	46.0	75.6	124.2	204.2	335.6	551.7	906.9	1,490.6	2,450.1	4,027.3
MWDSC San Diego	0	3.0	8.1	15.3	24.5	35.5	48.2	62.4	78.0	94.9	146.5	226.0	348.8	538.2	830.4	1,281.4	1,977.3	3,051.1	4,708.0	7,264.7	11,209.8
MWDSC Ventura	0	1.1	3.1	6.0	9.7	14.0	19.1	24.6	30.7	37.1	53.0	75.7	108.3	154.8	221.3	316.4	452.2	646.5	924.2	1,321.3	1,888.8
SCVWD	0	3.5	10.3	20.2	32.7	47.5	64.2	82.5	101.8	120.7	180.6	270.0	403.8	603.8	902.9	1,350.2	2,019.1	3,019.3	4,515.0	6,751.7	10,096.4
Zone 7	0	0.3	0.9	1.7	2.8	4.1	5.5	7.1	8.9	10.7	15.9	23.7	35.5	53.0	79.3	118.6	177.4	265.2	396.6	593.1	817.8
Total		23.1	64.3	122.3	195.6	282.9	382.8	493.7	613.5	739.3	1,070.3	1,594.8	2,392.2	3,614.0	5,496.1	8,406.6	12,920.5	19,936.8	30,861.3	47,895.3	81,938.9

Note:
These totals do not reflect the results of any failure scenarios. It is extremely unlikely that all agencies would experience a similar level of shortage under any scenario.

Table E-27
2030 Urban Shortage Cost per Month, $Millions 2005

Estimated Shortage %	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
ACWD	0	0.5	1.4	2.8	4.5	6.5	8.9	11.4	14.2	17.0	26.6	41.6	65.0	101.7	159.1	248.9	389.3	608.8	952.3	1,489.4	2,329.5
Antelope Valley East Kern	0	1.7	4.9	9.4	15.2	22.1	30.0	38.7	48.1	58.0	76.0	99.6	130.5	171.0	224.0	293.5	384.6	503.9	660.2	865.1	1,133.4
CCWD	0	2.4	7.3	14.2	23.1	33.5	45.1	57.7	69.9	82.3	116.5	164.8	233.1	329.8	466.6	660.2	934.1	1,321.6	1,869.9	2,645.6	3,743.1
EBMUD	0	2.5	7.5	14.6	23.6	34.3	46.4	59.6	73.5	87.1	133.8	205.6	315.9	485.4	745.7	1,145.6	1,760.0	2,704.0	4,154.3	6,382.4	9,805.5
MWDSC Los Angeles	0	8.1	22.0	41.3	65.7	94.9	128.7	166.7	208.6	254.0	412.2	668.8	1,085.1	1,760.7	2,856.9	4,635.6	7,521.7	12,204.7	19,803.2	32,132.6	52,138.1
MWDSC Orange	0	2.7	7.2	13.4	21.2	30.5	41.3	53.5	66.9	81.6	134.1	220.6	362.7	596.4	980.8	1,612.8	2,652.0	4,360.9	7,171.1	11,792.0	19,390.6
MWDSC Riverside	0	14	3.4	6.1	9.4	13.3	17.8	22.8	28.4	34.5	52.3	79.3	120.2	182.3	276.3	419.0	635.3	963.2	1,460.5	2,214.4	3,357.6
MWDSC San Bernardino	0	0.5	1.2	2.2	3.3	4.7	6.3	8.0	10.0	12.1	21.7	38.9	69.8	125.2	224.5	402.5	721.8	1,294.4	2,321.3	4,162.7	7,464.8
MWDSC San Diego	0	3.6	9.8	18.6	29.8	43.2	58.6	75.9	94.9	115.4	186.2	300.6	485.1	783.0	1,263.7	2,039.6	3,291.8	5,312.9	8,574.8	13,839.5	22,336.3
MWDSC Ventura	0	1.5	4.3	8.3	13.5	19.6	26.6	34.4	42.7	51.6	75.4	110.3	161.2	235.7	344.6	503.7	736.3	1,076.4	1,573.5	2,300.2	3,362.5
SCVWD	0	4.3	1.8	25.0	40.6	58.9	79.7	102.3	126.2	149.5	230.2	354.5	546.0	840.9	1,295.0	1,994.4	3,071.4	4,730.1	7,284.6	11,218.5	17,277.0
Zone 7	0	0.5	1.5	3.0	4.8	7.0	9.4	12.2	15.1	18.3	27.2	40.4	60.1	89.4	133.0	197.9	294.4	438.0	651.6	969.4	1,442.1
Tota.l		29.7	83.3	158.9	254.6	368.6	498.8	643.2	798.6	961.4	1,492.3	2,325.0	3,634.9	5,701.5	8,970.3	14,153.7	22,392.8	35,519.0	56,477.2	90,011.6	143,780.6

Appendix F
Other Infrastructure of Statewide Importance

Electric Transmission

Power System Outage on the Western Interconnection 1996

Western Systems Coordinating Council's study of 1996 outage reports that the disturbance led to the development of four isolated systems out of the normal Western System. The disturbance isolated two areas in which we are interested: (1) Northern California (north of Los Angeles) and (2) Southern Desert, consisting of southern California; southern Nevada; Arizona; New Mexico; El Paso, Texas and northern Baja California.

In the Northern California area, the report summarizes the consequences as follows: Load lost: 11,602 MW (388,017 MW-minutes, an average outage of 33 minutes) with 2,892,343 customers affected.

In the Southern Desert the report summarizes the consequences as follows: Load lost: 15,820 MW, (1.98 million MW-minutes, for an average outage of 125 minutes), with 4,195,972 customers affected.

Using the system average one-hour value for reliability, results in an estimated cost of $500 million dollars in today's dollars.

It should be noted that this cost is for a greater area than the State of California, and is extremely unlikely to happen as a result of flooding. It is most likely to happen as a result of earthquake unrelated to flooding, and if it occurred as a result of flooding it would likely be the result of a number of other, unconnected system problems that occurred to complicate the system response to flooding. However, it is reported here as a worst-case, low probability outcome from loss of the transmission lines due to flooding.

Appendix G
Economic Impacts

Methodology for Industrial Production Impacts

Intuitively, the impact of water shortages on industrial production will have the general form of an S curve, with industry being able to adjust to a low level of shortage with little to no impact on output. The effect on impact will then ramp up, at some level being faster than the change in shortage levels. Finally, at some level less than 100 percent shortage, production processes will be so impaired that production will cease. The blue line in Figure G-1 below shows a theoretical shape of this S curve. Indeed, different industries are likely to have curves that are different shapes, with some starting more slowly, or reaching a full cut off in production at an early or later stage, or both of these.

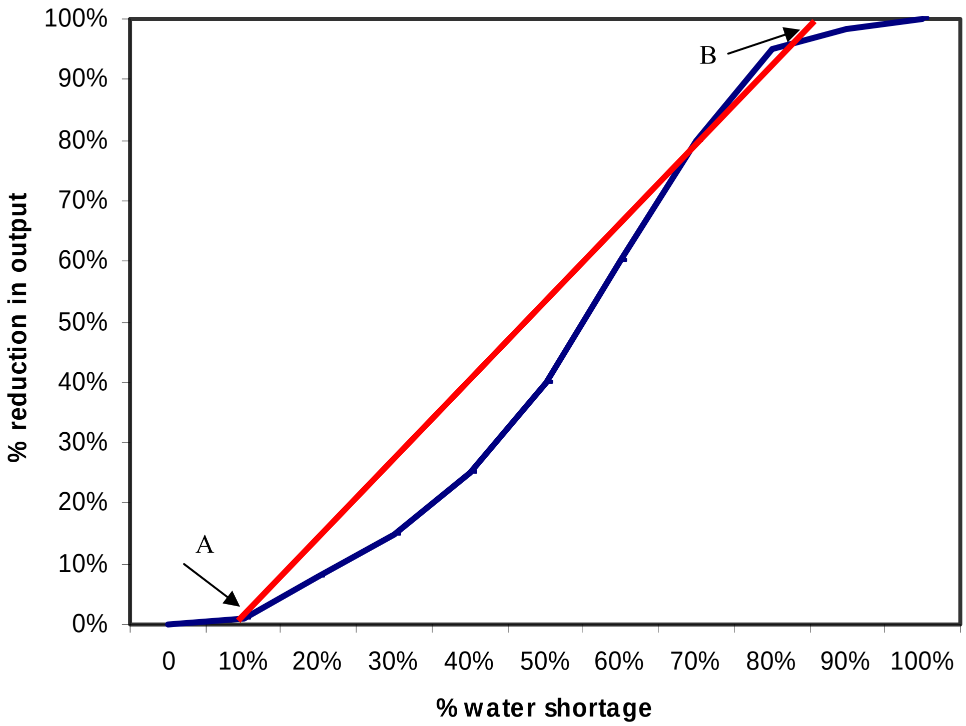

Figure G-1 Theoretical Relationship Between Shortage and Industrial Output Reductions

The figure also contains a red line, which is the approximation to this curve that will be developed for use in this analysis.

There is little empirical information about the specific shape of this curve. The only California study that has addressed the industrial response to water shortage is dated (California Urban Water Agencies 1991). It was published in 1991, when Californians were just beginning their current emphasis on conservation. That study conducted a survey of California industrial firms, and asked them the drop of production they would expect to experience under two shortage conditions, 0-15% and 15-30%. Using the midpoints of these ranges and the published elasticities results in the estimates of reductions in output as a result of shortages shown in Table G-1.

Table G-1
Percent Reduction In Output

Industry	% Reduction in Output at		
Shortage	7.5%	23%	Point A
Meat Packing	0.0%	0.0%	25%
Preserved Fruit & Vegetables	2.0%	7.9%	10%
Bakery Products	5.3%	20.3%	5%
Beverages	5.2%	25.7%	5%
Misc. Food and Kindred Products	1.8%	11.0%	10%
Paperboard Containers & Boxes	3.0%	15.8%	10%
Industrial Inorganic Chemicals	0.9%	4.5%	10%
Drugs	0.1%	7.2%	25%
Soap, Cleansers and Toilet Goods	2.9%	31.3%	10%
Paints and Allied Products	5.7%	21.8%	5%
Petroleum Refining	3.3%	19.1%	10%
Concrete, Gypsum, Plaster Products	1.3%	4.3%	25%
Fabricated Metal Products	1.1%	9.2%	10%
Computer and Office Equipment	1.4%	6.1%	10%
Communication Equipment	0.0%	0.2%	25%
Electronic Comp. and Accessories	0.5%	7.4%	10%
Motor Vehicles	0.0%	0.0%	25%
Aircraft & Parts	0.5%	6.8%	10%
Guided Missiles, Space Vehicles, Parts	0.0%	3.2%	25%

These results show the beginning of the accelerating lower portion of the curve, but say nothing about the shape of the curve above a 30 percent shortage.

To use these results to develop an approximate curve relating water shortages to decreases in output, we used a simple rule of thumb. The default assumption is that industry would begin to show a reduction in output at a ten percent shortage of water. Thus the resulting default "Point A" or first inflection point on the approximation was assumed to be at 10 percent, and shortages less than that were assumed to have no effect on output. For those industry that reported no effect at 15 percent, and little effect at 30 percent, the inflection point was assumed to be at 25 percent. Finally, for a few industries that showed stronger responses to shortage, the first inflection point was set at 5 percent.

There is no information to set the second inflection point (point B on the figure), which is that point at which production will be sufficiently curtailed that continued production is uneconomic. This point was arbitrarily set at 80 percent shortage. This is sufficiently severe that, given the protection given to industry, it is unlikely to be reached. However, fixing this allows the slope of the curve to be estimated.

The resulting equations for estimating reductions in industrial output are provided in Table G-2. These are equations of the form

$$O = a + bS$$

Where O is the proportionate decrease in output and S is the proportionate water shortage to industry. The resulting equations are provided in Table G-2

Table G-2
Industrial Output Reduction Equations

Industry	Equation Parameters	
Shortage	A	b
Meat Packing	-0.25	1.5625
Preserved Fruit & Vegetables	-0.10	1.375
Bakery Products	-0.05	1.3125
Beverages	-0.05	1.3125
Misc. Food and Kindred Products	-0.10	1.375
Paperboard Containers & Boxes	-0.10	1.375
Industrial Inorganic Chemicals	-0.10	1.375
Drugs	-0.25	1.5625
Soap, Cleansers and Toilet Goods	-0.10	1.375
Paints and Allied Products	-0.05	1.3125
Petroleum Refining	-0.10	1.375
Concrete, Gypsum, Plaster Products	-0.25	1.5625
Fabricated Metal Products	-0.10	1.375
Computer and Office Equipment	-0.10	1.375
Communication Equipment	-0.25	1.5625
Electronic Comp. and Accessories	-0.10	1.375
Motor Vehicles	-0.25	1.5625
Aircraft & Parts	-0.10	1.375
Guided Missiles, Space Vehicles, Parts	-0.25	1.5625

IMPLAN data and economic multipliers used in the analysis are provided in Table G-3 below. The employment multipliers are per job lost directly. The other multipliers are per dollar of output lost directly.

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Table G-3
California 2004 IMPLAN Multipliers by Industry

IMPLAN Sector Name	Employ-ment Multiplier	Output Multiplier	Total Labor Income per $ Output	Total Value Added per $ Output
Oilseed farming	1.47	1.58	$0.43	$0.97
Grain farming	1.35	1.61	$0.43	$0.91
Vegetable and melon farming	2.23	1.68	$0.64	$1.14
Tree nut farming	2.06	1.67	$0.59	$1.11
Fruit farming	1.79	1.78	$0.65	$1.04
Greenhouse and nursery production	1.84	1.89	$0.95	$1.29
Tobacco farming	na	0.00	$0.00	$0.00
Cotton farming	2.59	1.76	$0.52	$0.94
Sugarcane and sugar beet farming	1.27	1.79	$0.52	$0.88
All other crop farming	2.13	1.66	$0.49	$0.95
Cattle ranching and farming	1.99	1.99	$0.33	$0.63
Poultry and egg production	2.91	1.49	$0.34	$0.73
Animal production- except cattle and poultry	1.22	1.72	$0.33	$0.52
Logging	2.80	1.76	$0.45	$0.76
Forest nurseries- forest products- and timber	11.67	2.21	$0.65	$0.94
Fishing	1.40	2.33	$0.98	$1.15
Hunting and trapping	3.77	2.17	$0.63	$0.95
Agriculture and forestry support activities	1.29	2.01	$1.03	$1.22
Oil and gas extraction	2.49	1.52	$0.37	$0.86
Coal mining	3.06	1.59	$0.48	$0.91
Iron ore mining	2.52	1.72	$0.55	$0.80
Copper- nickel- lead- and zinc mining	1.90	1.74	$0.52	$0.78
Gold- silver- and other metal ore mining	2.96	1.56	$0.41	$0.88
Stone mining and quarrying	1.79	1.68	$0.55	$0.99
Sand- gravel- clay- and refractory mining	1.78	1.68	$0.60	$1.04
Other nonmetallic mineral mining	1.94	1.70	$0.55	$0.92
Drilling oil and gas wells	3.40	1.65	$0.34	$0.89
Support activities for oil and gas operations	1.70	1.55	$0.53	$1.14
Support activities for other mining	2.51	1.79	$0.63	$1.05
Power generation and supply	3.94	1.44	$0.35	$0.93
Natural gas distribution	3.24	1.41	$0.30	$0.63
Water- sewage and other systems	2.47	1.82	$0.73	$1.23
New residential 1-unit structures- all	2.13	1.94	$0.71	$1.01
New multifamily housing structures- all	1.71	1.93	$0.92	$1.20
New residential additions and alterations-all	2.40	1.88	$0.58	$0.84
New farm housing units	na	0.00	$0.00	$0.00
Manufacturing and industrial buildings	1.66	1.85	$0.87	$1.18

Table G-3
California 2004 IMPLAN Multipliers by Industry

IMPLAN Sector Name	Employ-ment Multiplier	Output Multiplier	Total Labor Income per $ Output	Total Value Added per $ Output
Commercial and institutional buildings	1.81	1.94	$0.85	$1.16
Highway- street- bridge- and tunnel construct	1.79	1.92	$0.79	$1.09
Water- sewer- and pipeline construction	1.90	1.91	$0.76	$1.05
Other new construction	1.90	1.98	$0.84	$1.15
Maintenance and repair of farm and nonfarm re	1.99	1.87	$0.68	$0.95
Maintenance and repair of nonresidential buil	1.93	1.95	$0.79	$1.10
Maintenance and repair of highways- streets-	1.84	1.98	$0.81	$1.12
Other maintenance and repair construction	1.71	1.93	$0.92	$1.23
Dog and cat food manufacturing	4.86	1.61	$0.26	$0.49
Other animal food manufacturing	3.87	1.70	$0.30	$0.47
Flour milling	5.35	1.82	$0.36	$0.63
Rice milling	4.53	1.84	$0.38	$0.64
Malt manufacturing	6.64	1.78	$0.37	$0.63
Wet corn milling	7.03	1.80	$0.33	$0.59
Soybean processing	10.40	1.55	$0.20	$0.34
Other oilseed processing	13.59	1.88	$0.34	$0.60
Fats and oils refining and blending	4.93	1.44	$0.17	$0.31
Breakfast cereal manufacturing	8.17	2.07	$0.46	$0.74
Sugar manufacturing	5.78	2.10	$0.44	$0.69
Confectionery manufacturing from cacao beans	4.21	2.02	$0.43	$0.77
Confectionery manufacturing from purchased chocolate	3.26	2.05	$0.45	$0.84
Nonchocolate confectionery manufacturing	2.89	1.95	$0.48	$0.87
Frozen food manufacturing	2.86	1.97	$0.45	$0.78
Fruit and vegetable canning and drying	3.61	1.89	$0.41	$0.74
Fluid milk manufacturing	6.86	2.40	$0.45	$0.73
Creamery butter manufacturing	5.84	2.79	$0.49	$0.77
Cheese manufacturing	8.64	2.60	$0.41	$0.69
Dry- condensed- and evaporated dairy products	7.52	2.18	$0.37	$0.75
Ice cream and frozen dessert manufacturing	4.22	2.19	$0.43	$0.78
Animal- except poultry- slaughtering	4.74	2.24	$0.37	$0.59
Meat processed from carcasses	3.98	2.00	$0.39	$0.63
Rendering and meat byproduct processing	3.90	2.01	$0.38	$0.77
Poultry processing	2.00	1.83	$0.43	$0.62
Seafood product preparation and packaging	2.60	1.82	$0.46	$0.65
Frozen cakes and other pastries manufacturing	2.14	2.04	$0.66	$0.94
Bread and bakery product- except frozen- manu	1.82	1.85	$0.57	$0.92
Cookie and cracker manufacturing	2.81	1.80	$0.38	$0.74

Table G-3
California 2004 IMPLAN Multipliers by Industry

IMPLAN Sector Name	Employ-ment Multiplier	Output Multiplier	Total Labor Income per $ Output	Total Value Added per $ Output
Mixes and dough made from purchased flour	2.99	1.78	$0.38	$0.69
Dry pasta manufacturing	2.87	1.83	$0.39	$0.76
Tortilla manufacturing	1.89	1.78	$0.48	$0.80
Roasted nuts and peanut butter manufacturing	4.78	2.15	$0.48	$0.89
Other snack food manufacturing	4.29	1.85	$0.39	$0.79
Coffee and tea manufacturing	4.95	2.14	$0.50	$0.76
Flavoring syrup and concentrate manufacturing	8.34	1.77	$0.27	$0.72
Mayonnaise- dressing- and sauce manufacturing	3.14	1.98	$0.42	$0.75
Spice and extract manufacturing	3.76	1.87	$0.44	$0.83
All other food manufacturing	2.69	1.98	$0.47	$0.74
Soft drink and ice manufacturing	4.20	1.99	$0.42	$0.73
Breweries	5.53	1.71	$0.35	$0.81
Wineries	3.31	1.87	$0.49	$0.80
Distilleries	5.46	1.61	$0.29	$0.92
Tobacco stemming and redrying	na	0.00	$0.00	$0.00
Cigarette manufacturing	na	0.00	$0.00	$0.00
Other tobacco product manufacturing	6.38	1.89	$0.34	$0.74
Fiber- yarn- and thread mills	1.94	1.60	$0.35	$0.52
Broadwoven fabric mills	1.86	1.69	$0.45	$0.64
Narrow fabric mills and schiffli embroidery	1.56	1.69	$0.56	$0.80
Nonwoven fabric mills	2.14	1.59	$0.36	$0.58
Knit fabric mills	1.72	1.64	$0.40	$0.57
Textile and fabric finishing mills	2.02	1.79	$0.43	$0.60
Fabric coating mills	2.35	1.68	$0.44	$0.76
Carpet and rug mills	2.29	1.49	$0.28	$0.55
Curtain and linen mills	1.76	1.66	$0.41	$0.69
Textile bag and canvas mills	1.79	1.92	$0.63	$0.89
Tire cord and tire fabric mills	1.91	1.51	$0.29	$0.48
Other miscellaneous textile product mills	1.78	1.83	$0.56	$0.79
Sheer hosiery mills	1.71	1.63	$0.45	$0.63
Other hosiery and sock mills	1.67	1.72	$0.61	$0.82
Other apparel knitting mills	1.67	1.74	$0.57	$0.75
Cut and sew apparel manufacturing	1.86	1.83	$0.52	$0.83
Accessories and other apparel manufacturing	1.83	1.90	$0.67	$0.94
Leather and hide tanning and finishing	2.42	1.96	$0.47	$0.71
Footwear manufacturing	1.82	2.02	$0.67	$0.86
Other leather product manufacturing	1.73	1.76	$0.56	$0.93
Sawmills	2.66	1.88	$0.44	$0.81

Table G-3
California 2004 IMPLAN Multipliers by Industry

IMPLAN Sector Name	Employ-ment Multiplier	Output Multiplier	Total Labor Income per $ Output	Total Value Added per $ Output
Wood preservation	2.87	2.11	$0.45	$0.70
Reconstituted wood product manufacturing	1.99	1.67	$0.44	$0.86
Veneer and plywood manufacturing	2.16	2.06	$0.50	$0.76
Engineered wood member and truss manufacturing	1.85	1.74	$0.47	$0.90
Wood windows and door manufacturing	2.01	1.79	$0.49	$0.91
Cut stock- resawing lumber- and planning	1.99	2.05	$0.56	$0.83
Other millwork- including flooring	2.10	2.01	$0.55	$0.82
Wood container and pallet manufacturing	1.71	2.03	$0.61	$0.92
Manufactured home- mobile home- manufacturing	1.71	1.57	$0.50	$0.77
Prefabricated wood building manufacturing	1.92	1.88	$0.58	$0.83
Miscellaneous wood product manufacturing	1.70	1.81	$0.52	$0.93
Pulp mills	4.80	2.09	$0.47	$0.74
Paper and paperboard mills	4.05	1.91	$0.42	$0.72
Paperboard container manufacturing	2.32	1.63	$0.45	$0.63
Flexible packaging foil manufacturing	2.82	1.96	$0.47	$0.69
Surface-coated paperboard manufacturing	2.81	1.83	$0.49	$0.61
Coated and laminated paper and packaging mate	2.85	1.79	$0.45	$0.71
Coated and uncoated paper bag manufacturing	2.47	1.77	$0.47	$0.69
Die-cut paper office supplies manufacturing	2.48	1.78	$0.56	$0.77
Envelope manufacturing	2.48	1.82	$0.52	$0.75
Stationery and related product manufacturing	2.22	1.72	$0.49	$0.71
Sanitary paper product manufacturing	4.03	1.75	$0.36	$0.63
All other converted paper product manufacturi	2.38	1.78	$0.48	$0.76
Manifold business forms printing	1.84	1.71	$0.60	$0.91
Books printing	1.71	1.61	$0.56	$1.04
Blankbook and looseleaf binder manufacturing	1.79	1.90	$0.61	$0.86
Commercial printing	1.58	1.83	$0.82	$1.16
Tradebinding and related work	1.47	1.97	$0.82	$1.11
Prepress services	1.95	1.98	$0.87	$1.21
Petroleum refineries	11.73	1.50	$0.16	$0.29
Asphalt paving mixture and block manufacturin	4.32	2.29	$0.43	$0.58
Asphalt shingle and coating materials manufac	3.83	2.07	$0.41	$0.63
Petroleum lubricating oil and grease manufact	4.59	2.28	$0.42	$0.60
All other petroleum and coal products manufac	3.29	1.97	$0.29	$0.47
Petrochemical manufacturing	19.95	2.09	$0.23	$0.44
Industrial gas manufacturing	6.39	1.90	$0.41	$0.85
Synthetic dye and pigment manufacturing	3.80	1.96	$0.45	$0.70
Other basic inorganic chemical manufacturing	3.94	1.96	$0.53	$0.84

Table G-3
California 2004 IMPLAN Multipliers by Industry

IMPLAN Sector Name	Employ-ment Multiplier	Output Multiplier	Total Labor Income per $ Output	Total Value Added per $ Output
Other basic organic chemical manufacturing	5.48	2.05	$0.36	$0.57
Plastics material and resin manufacturing	5.00	1.94	$0.27	$0.46
Synthetic rubber manufacturing	3.73	1.98	$0.30	$0.54
Cellulosic organic fiber manufacturing	4.03	1.91	$0.38	$0.61
Noncellulosic organic fiber manufacturing	3.57	1.87	$0.41	$0.64
Nitrogenous fertilizer manufacturing	4.12	1.62	$0.22	$0.41
Phosphatic fertilizer manufacturing	5.42	1.83	$0.36	$0.53
Fertilizer- mixing only- manufacturing	2.67	1.66	$0.33	$0.52
Pesticide and other agricultural chemical man	7.09	1.82	$0.33	$0.68
Pharmaceutical and medicine manufacturing	7.02	2.14	$0.48	$0.88
Paint and coating manufacturing	3.46	1.70	$0.34	$0.56
Adhesive manufacturing	3.38	1.88	$0.46	$0.70
Soap and other detergent manufacturing	6.50	2.02	$0.41	$0.76
Polish and other sanitation good manufacturin	6.94	1.93	$0.41	$0.84
Surface active agent manufacturing	5.95	2.14	$0.38	$0.63
Toilet preparation manufacturing	4.46	1.99	$0.43	$0.82
Printing ink manufacturing	3.05	1.83	$0.45	$0.64
Explosives manufacturing	2.18	1.79	$0.58	$0.85
Custom compounding of purchased resins	2.52	1.66	$0.35	$0.52
Photographic film and chemical manufacturing	3.57	1.88	$0.46	$0.77
Other miscellaneous chemical product manufact	3.57	2.01	$0.47	$0.71
Plastics packaging materials- film and sheet	2.14	1.60	$0.36	$0.65
Plastics pipe- fittings- and profile shapes	2.21	1.57	$0.36	$0.64
Laminated plastics plate- sheet- and shapes	2.19	1.77	$0.48	$0.81
Plastics bottle manufacturing	2.08	1.55	$0.35	$0.68
Resilient floor covering manufacturing	2.17	1.58	$0.45	$0.89
Plastics plumbing fixtures and all other plas	1.88	1.68	$0.47	$0.80
Foam product manufacturing	2.05	1.69	$0.40	$0.72
Tire manufacturing	1.98	1.60	$0.38	$0.58
Rubber and plastics hose and belting manufact	1.91	1.62	$0.45	$0.78
Other rubber product manufacturing	1.81	1.64	$0.44	$0.72
Vitreous china plumbing fixture manufacturing	1.79	1.80	$0.54	$0.93
Vitreous china and earthenware articles manuf	1.57	1.96	$0.77	$1.06
Porcelain electrical supply manufacturing	2.16	1.93	$0.63	$0.97
Brick and structural clay tile manufacturing	2.05	1.85	$0.55	$0.96
Ceramic wall and floor tile manufacturing	1.99	1.90	$0.52	$0.87
Nonclay refractory manufacturing	2.83	1.68	$0.53	$0.92
Clay refractory and other structural clay pro	2.20	1.82	$0.53	$0.80

Table G-3
California 2004 IMPLAN Multipliers by Industry

IMPLAN Sector Name	Employ-ment Multiplier	Output Multiplier	Total Labor Income per $ Output	Total Value Added per $ Output
Glass container manufacturing	2.63	1.78	$0.50	$0.89
Glass and glass products- except glass contai	2.29	1.87	$0.52	$0.92
Cement manufacturing	3.33	1.64	$0.35	$0.83
Ready-mix concrete manufacturing	2.43	1.73	$0.50	$0.79
Concrete block and brick manufacturing	2.28	1.78	$0.52	$0.85
Concrete pipe manufacturing	2.19	1.68	$0.50	$0.85
Other concrete product manufacturing	1.92	1.73	$0.58	$0.90
Lime manufacturing	2.65	1.80	$0.43	$0.78
Gypsum product manufacturing	2.95	1.64	$0.35	$0.68
Abrasive product manufacturing	2.18	1.78	$0.47	$0.85
Cut stone and stone product manufacturing	1.76	1.95	$0.75	$0.98
Ground or treated minerals and earths manufac	2.59	1.57	$0.35	$0.89
Mineral wool manufacturing	2.48	1.73	$0.43	$0.84
Miscellaneous nonmetallic mineral products	2.18	1.63	$0.41	$0.83
Iron and steel mills	4.66	1.78	$0.36	$0.65
Ferroalloy and related product manufacturing	3.09	1.61	$0.30	$0.73
Iron- steel pipe and tube from purchased stee	2.75	1.54	$0.35	$0.69
Rolled steel shape manufacturing	3.47	1.60	$0.35	$0.55
Steel wire drawing	2.72	1.50	$0.31	$0.68
Alumina refining	4.71	2.08	$0.38	$0.65
Primary aluminum production	3.59	1.87	$0.35	$0.58
Secondary smelting and alloying of aluminum	5.95	1.97	$0.43	$0.71
Aluminum sheet- plate- and foil manufacturing	3.36	1.46	$0.23	$0.38
Aluminum extruded product manufacturing	2.05	1.49	$0.39	$0.55
Other aluminum rolling and drawing	2.77	1.35	$0.24	$0.45
Primary smelting and refining of copper	Na	0.00	$0.00	$0.00
Primary nonferrous metal- except copper and a	3.06	1.71	$0.39	$0.55
Copper rolling- drawing- and extruding	3.07	1.53	$0.30	$0.47
Copper wire- except mechanical- drawing	3.35	1.55	$0.30	$0.50
Secondary processing of copper	4.81	1.96	$0.43	$0.66
Nonferrous metal- except copper and aluminum-	2.35	1.57	$0.36	$0.50
Secondary processing of other nonferrous	3.51	2.04	$0.57	$0.81
Ferrous metal foundaries	2.26	1.92	$0.62	$0.92
Aluminum foundries	1.90	1.76	$0.57	$0.76
Nonferrous foundries- except aluminum	1.87	1.72	$0.55	$0.79
Iron and steel forging	2.05	1.68	$0.49	$0.75
Nonferrous forging	2.06	1.61	$0.48	$0.76
Custom roll forming	2.77	1.54	$0.36	$0.64

Table G-3
California 2004 IMPLAN Multipliers by Industry

IMPLAN Sector Name	Employ-ment Multiplier	Output Multiplier	Total Labor Income per $ Output	Total Value Added per $ Output
All other forging and stamping	1.93	1.71	$0.52	$0.79
Cutlery and flatware- except precious- manufa	2.39	1.81	$0.52	$0.92
Hand and edge tool manufacturing	2.11	1.78	$0.54	$0.89
Saw blade and handsaw manufacturing	1.98	1.77	$0.51	$0.84
Kitchen utensil- pot- and pan manufacturing	2.09	1.72	$0.54	$0.76
Prefabricated metal buildings and components	1.98	1.66	$0.47	$0.64
Fabricated structural metal manufacturing	1.92	1.60	$0.46	$0.74
Plate work manufacturing	1.98	1.63	$0.46	$0.79
Metal window and door manufacturing	1.81	1.69	$0.52	$0.79
Sheet metal work manufacturing	1.83	1.64	$0.50	$0.80
Ornamental and architectural metal work manuf	1.86	1.67	$0.52	$0.82
Power boiler and heat exchanger manufacturing	2.02	1.67	$0.51	$0.81
Metal tank- heavy gauge- manufacturing	1.89	1.71	$0.55	$0.83
Metal can- box- and other container manufactu	2.79	1.55	$0.33	$0.53
Hardware manufacturing	2.05	1.63	$0.46	$0.79
Spring and wire product manufacturing	1.81	1.63	$0.48	$0.76
Machine shops	1.82	1.90	$0.76	$1.01
Turned product and screw- nut- and bolt manuf	1.98	1.72	$0.57	$0.89
Metal heat treating	2.08	1.85	$0.54	$0.89
Metal coating and nonprecious engraving	1.76	1.71	$0.49	$0.78
Electroplating- anodizing- and coloring metal	1.88	1.85	$0.55	$0.93
Metal valve manufacturing	2.24	1.65	$0.48	$0.84
Ball and roller bearing manufacturing	2.42	1.76	$0.50	$0.83
Small arms manufacturing	2.06	1.79	$0.62	$0.97
Other ordnance and accessories manufacturing	2.56	1.70	$0.50	$0.97
Fabricated pipe and pipe fitting manufacturing	1.84	1.67	$0.50	$0.79
Industrial pattern manufacturing	2.08	1.80	$0.55	$0.97
Enameled iron and metal sanitary ware manufac	2.00	1.67	$0.50	$0.88
Miscellaneous fabricated metal product manufa	1.88	1.71	$0.51	$0.78
Ammunition manufacturing	2.50	1.91	$0.59	$0.85
Farm machinery and equipment manufacturing	2.54	1.66	$0.37	$0.62
Lawn and garden equipment manufacturing	2.49	1.63	$0.32	$0.53
Construction machinery manufacturing	3.29	1.62	$0.30	$0.50
Mining machinery and equipment manufacturing	2.13	1.70	$0.53	$0.75
Oil and gas field machinery and equipment	2.37	1.79	$0.51	$0.71
Sawmill and woodworking machinery	1.89	1.86	$0.58	$0.77
Plastics and rubber industry machinery	2.10	1.83	$0.54	$0.80
Paper industry machinery manufacturing	2.35	1.89	$0.66	$0.85

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California 2004 IMPLAN Multipliers by Industry

IMPLAN Sector Name	Employ-ment Multiplier	Output Multiplier	Total Labor Income per $ Output	Total Value Added per $ Output
Textile machinery manufacturing	1.78	1.87	$0.52	$0.76
Printing machinery and equipment manufacturin	2.29	1.91	$0.60	$0.80
Food product machinery manufacturing	2.14	1.92	$0.62	$0.87
Semiconductor machinery manufacturing	5.17	1.76	$0.49	$0.74
All other industrial machinery manufacturing	2.28	1.86	$0.64	$0.86
Office machinery manufacturing	3.53	1.97	$0.54	$0.80
Optical instrument and lens manufacturing	2.74	2.01	$0.76	$1.04
Photographic and photocopying equipment manuf	3.66	1.93	$0.47	$0.74
Other commercial and service industry machine	2.52	1.88	$0.55	$0.78
Automatic vending- commercial laundry and dry	2.12	1.77	$0.49	$0.73
Air purification equipment manufacturing	1.86	1.75	$0.53	$0.79
Industrial and commercial fan and blower manu	2.36	1.73	$0.63	$0.92
Heating equipment- except warm air furnaces	2.13	1.73	$0.48	$0.81
AC- refrigeration- and forced air heating	2.44	1.69	$0.43	$0.63
Industrial mold manufacturing	1.82	1.97	$0.80	$1.04
Metal cutting machine tool manufacturing	2.52	1.84	$0.70	$0.96
Metal forming machine tool manufacturing	1.91	1.86	$0.67	$0.92
Special tool- die- jig- and fixture manufactu	1.90	2.03	$0.85	$1.08
Cutting tool and machine tool accessory manuf	1.84	1.93	$0.69	$0.93
Rolling mill and other metalworking machinery	2.01	1.80	$0.52	$0.74
Turbine and turbine generator set units manuf	3.15	1.65	$0.42	$0.72
Other engine equipment manufacturing	3.25	1.59	$0.29	$0.50
Speed changers and mechanical power transmiss	2.21	1.82	$0.67	$0.94
Pump and pumping equipment manufacturing	2.47	1.71	$0.46	$0.72
Air and gas compressor manufacturing	2.41	1.67	$0.42	$0.68
Measuring and dispensing pump manufacturing	2.58	1.80	$0.55	$0.79
Elevator and moving stairway manufacturing	2.34	1.72	$0.46	$0.66
Conveyor and conveying equipment manufacturing	2.28	1.73	$0.47	$0.74
Overhead cranes- hoists- and monorail systems	2.10	1.69	$0.44	$0.66
Industrial truck- trailer- and stacker manufa	2.30	1.83	$0.49	$0.63
Power-driven handtool manufacturing	2.45	1.88	$0.54	$0.82
Welding and soldering equipment manufacturing	2.30	1.71	$0.54	$0.75
Packaging machinery manufacturing	2.07	1.85	$0.65	$0.89
Industrial process furnace and oven manufactu	2.04	1.83	$0.69	$0.94
Fluid power cylinder and actuator manufacturi	2.32	1.76	$0.58	$0.89
Fluid power pump and motor manufacturing	2.74	1.84	$0.61	$0.90
Scales- balances- and miscellaneous general p	2.26	1.79	$0.55	$0.82
Electronic computer manufacturing	8.47	2.31	$0.54	$0.74

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California 2004 IMPLAN Multipliers by Industry

IMPLAN Sector Name	Employ-ment Multiplier	Output Multiplier	Total Labor Income per $ Output	Total Value Added per $ Output
Computer storage device manufacturing	5.31	2.21	$0.55	$0.78
Computer terminal manufacturing	3.92	2.53	$0.84	$0.80
Other computer peripheral equipment manufactu	3.91	2.19	$0.64	$0.83
Telephone apparatus manufacturing	6.83	2.08	$0.53	$0.79
Broadcast and wireless communications equipme	4.24	2.08	$0.58	$0.82
Other communications equipment manufacturing	3.46	2.04	$0.66	$0.91
Audio and video equipment manufacturing	5.68	2.08	$0.49	$0.70
Electron tube manufacturing	3.50	2.12	$0.74	$0.94
Semiconductors and related device manufacturi	4.73	2.06	$0.66	$0.96
All other electronic component manufacturing	2.55	2.03	$0.67	$0.89
Electromedical apparatus manufacturing	3.75	1.99	$0.63	$0.86
Search- detection- and navigation instruments	3.34	2.09	$0.74	$0.99
Automatic environmental control manufacturing	2.75	1.98	$0.60	$0.83
Industrial process variable instruments	2.82	2.08	$0.71	$0.95
Totalizing fluid meters and counting devices	3.12	1.86	$0.50	$0.69
Electricity and signal testing instruments	3.19	2.03	$0.77	$1.00
Analytical laboratory instrument manufacturin	3.69	2.10	$0.74	$0.97
Irradiation apparatus manufacturing	4.37	2.17	$0.65	$0.88
Watch- clock- and other measuring and control	2.70	2.02	$0.64	$0.86
Software reproducing	3.53	2.10	$0.66	$0.89
Audio and video media reproduction	2.72	2.09	$0.65	$0.89
Magnetic and optical recording media manufact	4.41	2.05	$0.68	$0.86
Electric lamp bulb and part manufacturing	2.27	1.84	$0.53	$0.89
Lighting fixture manufacturing	2.27	1.80	$0.53	$0.82
Electric housewares and household fan manufac	2.48	1.75	$0.40	$0.72
Household vacuum cleaner manufacturing	2.43	1.71	$0.41	$0.76
Household cooking appliance manufacturing	3.17	1.61	$0.43	$0.82
Household refrigerator and home freezer manuf	2.36	1.68	$0.41	$0.63
Household laundry equipment manufacturing	2.67	1.53	$0.26	$0.41
Other major household appliance manufacturing	2.89	1.80	$0.42	$0.74
Electric power and specialty transformer manu	2.40	1.83	$0.57	$0.86
Motor and generator manufacturing	2.24	1.69	$0.47	$0.79
Switchgear and switchboard apparatus manufact	2.32	1.65	$0.48	$0.90
Relay and industrial control manufacturing	2.69	1.91	$0.58	$0.82
Storage battery manufacturing	2.38	1.79	$0.54	$0.79
Primary battery manufacturing	2.80	1.61	$0.41	$0.90
Fiber optic cable manufacturing	3.31	1.65	$0.40	$0.83
Other communication and energy wire manufactu	2.26	1.51	$0.33	$0.61

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California 2004 IMPLAN Multipliers by Industry

IMPLAN Sector Name	Employ-ment Multiplier	Output Multiplier	Total Labor Income per $ Output	Total Value Added per $ Output
Wiring device manufacturing	2.21	1.61	$0.45	$0.88
Carbon and graphite product manufacturing	2.07	1.64	$0.48	$0.95
Miscellaneous electrical equipment manufacturing	2.64	2.06	$0.73	$0.93
Automobile and light truck manufacturing	6.15	1.57	$0.27	$0.44
Heavy duty truck manufacturing	3.69	1.52	$0.24	$0.39
Motor vehicle body manufacturing	2.40	1.71	$0.44	$0.53
Truck trailer manufacturing	2.27	1.71	$0.52	$0.67
Motor home manufacturing	1.70	1.35	$0.27	$0.31
Travel trailer and camper manufacturing	1.92	1.76	$0.49	$0.64
Motor vehicle parts manufacturing	2.59	1.72	$0.43	$0.62
Aircraft manufacturing	3.79	1.90	$0.58	$0.75
Aircraft engine and engine parts manufacturing	2.92	1.68	$0.48	$0.74
Other aircraft parts and equipment	2.57	1.89	$0.64	$0.91
Guided missile and space vehicle manufacturing	3.39	2.05	$0.80	$1.02
Propulsion units and parts for space vehicles	2.63	2.25	$1.01	$1.19
Railroad rolling stock manufacturing	2.47	1.60	$0.44	$0.60
Ship building and repairing	2.04	1.89	$0.69	$0.91
Boat building	1.92	1.64	$0.46	$0.69
Motorcycle- bicycle- and parts manufacturing	2.21	1.38	$0.24	$0.35
Military armored vehicles and tank parts manufactur.	3.24	1.78	$0.55	$0.76
All other transportation equipment manufacturing	3.21	1.61	$0.33	$0.61
Wood kitchen cabinet and countertop manufacturing	1.86	1.86	$0.61	$0.89
Upholstered household furniture manufacturing	1.90	2.04	$0.62	$0.85
Non-upholstered wood household furniture manufac.	1.79	1.84	$0.52	$0.79
Metal household furniture manufacturing	1.93	1.77	$0.49	$0.82
Institutional furniture manufacturing	1.93	1.91	$0.59	$0.90
Other household and institutional furniture	1.84	1.73	$0.44	$0.69
Wood office furniture manufacturing	2.15	1.94	$0.49	$0.81
Custom architectural woodwork and millwork	1.87	1.89	$0.72	$1.04
Office furniture- except wood- manufacturing	2.25	1.79	$0.48	$0.82
Showcases- partitions- shelving- and lockers	1.79	1.78	$0.56	$0.87
Mattress manufacturing	2.55	1.98	$0.48	$0.78
Blind and shade manufacturing	1.85	1.85	$0.54	$0.80
Laboratory apparatus and furniture manufacturing	2.70	2.09	$0.78	$0.98
Surgical and medical instrument manufacturing	3.15	1.88	$0.64	$1.06
Surgical appliance and supplies manufacturing	2.64	1.89	$0.62	$1.00
Dental equipment and supplies manufacturing	2.40	1.90	$0.67	$0.98
Ophthalmic goods manufacturing	2.26	1.83	$0.61	$1.03

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California 2004 IMPLAN Multipliers by Industry

IMPLAN Sector Name	Employ- ment Multiplier	Output Multiplier	Total Labor Income per $ Output	Total Value Added per $ Output
Dental laboratories	1.62	1.96	$0.93	$1.25
Jewelry and silverware manufacturing	1.91	1.74	$0.50	$0.69
Sporting and athletic goods manufacturing	2.33	1.94	$0.63	$0.87
Doll- toy- and game manufacturing	3.18	1.78	$0.60	$0.96
Office supplies- except paper- manufacturing	1.95	1.82	$0.60	$0.96
Sign manufacturing	1.69	1.96	$0.82	$1.09
Gasket- packing- and sealing device manufacturing	1.80	1.80	$0.66	$0.88
Musical instrument manufacturing	2.05	2.23	$0.90	$1.10
Broom- brush- and mop manufacturing	1.98	1.81	$0.60	$0.89
Burial casket manufacturing	1.56	1.68	$0.55	$0.94
Buttons- pins- and all other miscellaneous ma	1.78	1.88	$0.70	$0.93
Wholesale trade	2.11	1.81	$0.66	$1.16
Air transportation	2.77	2.05	$0.64	$0.98
Rail transportation	2.49	1.75	$0.60	$1.04
Water transportation	5.13	1.96	$0.54	$0.89
Truck transportation	1.94	2.08	$0.71	$1.06
Transit and ground passenger transportation	1.35	1.94	$0.74	$1.12
Pipeline transportation	7.66	2.02	$0.58	$0.90
Scenic and sightseeing transportation and sup	1.72	1.89	$1.04	$1.41
Postal service	1.54	2.00	$1.10	$1.39
Couriers and messengers	1.52	1.96	$0.76	$1.15
Warehousing and storage	1.57	2.00	$0.94	$1.27
Motor vehicle and parts dealers	1.87	1.93	$0.79	$1.20
Furniture and home furnishings stores	1.67	1.86	$0.66	$1.14
Electronics and appliance stores	1.66	1.92	$0.90	$1.30
Building material and garden supply stores	1.67	1.89	$0.70	$1.15
Food and beverage stores	1.55	1.93	$0.78	$1.20
Health and personal care stores	1.55	1.95	$0.80	$1.21
Gasoline stations	1.95	1.78	$0.58	$1.11
Clothing and clothing accessories stores	1.53	1.80	$0.60	$1.11
Sporting goods- hobby- book and music stores	1.38	1.91	$0.74	$1.18
General merchandise stores	1.44	1.95	$0.76	$1.17
Miscellaneous store retailers	1.30	1.84	$0.79	$1.25
Nonstore retailers	1.30	1.62	$0.43	$1.06
Newpaper publishers	1.81	1.87	$0.75	$1.06
Periodical publishers	2.62	1.91	$0.63	$0.95
Book publishers	2.91	1.91	$0.57	$0.90
Database- directory- and other publishers	2.83	1.77	$0.47	$0.91

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California 2004 IMPLAN Multipliers by Industry

IMPLAN Sector Name	Employ-ment Multiplier	Output Multiplier	Total Labor Income per $ Output	Total Value Added per $ Output
Software publishers	4.31	1.90	$0.65	$1.07
Motion picture and video industries	3.01	2.26	$0.84	$1.20
Sound recording industries	3.63	1.58	$0.34	$1.05
Radio and television broadcasting	3.08	2.26	$0.90	$1.19
Cable networks and program distribution	4.44	1.72	$0.23	$0.81
Telecommunications	3.35	1.77	$0.47	$0.98
Information services	4.76	1.95	$0.74	$1.10
Data processing services	3.03	1.98	$0.76	$1.12
Nondepository credit intermediation and rela	2.51	1.87	$0.75	$1.20
Securities- commodity contracts- investments	2.39	2.23	$1.09	$1.32
Insurance carriers	2.80	2.01	$0.67	$1.04
Insurance agencies- brokerages- and related	1.86	1.72	$0.69	$1.20
Funds- trusts- and other financial vehicles	4.38	2.36	$0.85	$1.09
Monetary authorities and depository credit in	2.22	1.58	$0.45	$1.11
Real estate	1.92	1.57	$0.37	$1.04
Automotive equipment rental and leasing	2.38	1.97	$0.58	$1.01
Video tape and disc rental	1.45	2.01	$0.68	$1.09
Machinery and equipment rental and leasing	3.56	1.91	$0.54	$1.03
General and consumer goods rental except vide	1.67	2.17	$1.02	$1.27
Lessors of nonfinancial intangible assets	8.40	1.31	$0.20	$0.98
Legal services	2.08	1.95	$0.86	$1.26
Accounting and bookkeeping services	1.79	2.10	$0.90	$1.22
Architectural and engineering services	2.12	2.15	$0.98	$1.28
Specialized design services	2.02	1.89	$0.69	$1.15
Custom computer programming services	1.98	2.34	$1.52	$1.59
Computer systems design services	1.90	2.31	$1.50	$1.58
Other computer related services- including fa	1.82	1.55	$0.54	$1.18
Management consulting services	2.15	2.07	$0.91	$1.23
Environmental and other technical consulting	2.41	2.02	$0.77	$1.16
Scientific research and development services	2.11	2.12	$1.06	$1.29
Advertising and related services	2.15	2.13	$0.83	$1.18
Photographic services	1.51	1.82	$0.58	$1.08
Veterinary services	1.43	1.95	$0.73	$0.97
All other miscellaneous professional and tech	4.76	1.88	$0.42	$0.96
Management of companies and enterprises	2.36	1.95	$0.79	$1.20
Office administrative services	2.48	1.93	$0.68	$1.13
Facilities support services	1.62	2.00	$0.97	$1.31
Employment services	1.26	2.07	$1.24	$1.50

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California 2004 IMPLAN Multipliers by Industry

IMPLAN Sector Name	Employ-ment Multiplier	Output Multiplier	Total Labor Income per $ Output	Total Value Added per $ Output
Business support services	1.57	1.98	$0.82	$1.20
Travel arrangement and reservation services	2.04	2.03	$0.68	$1.08
Investigation and security services	1.31	2.01	$1.00	$1.32
Services to buildings and dwellings	1.47	2.04	$0.80	$1.15
Other support services	1.81	1.86	$0.59	$1.05
Waste management and remediation services	2.11	1.95	$0.60	$1.03
Elementary and secondary schools	1.36	2.27	$1.18	$1.38
Colleges- universities- and junior colleges	1.53	2.09	$0.93	$1.22
Other educational services	1.40	1.88	$0.73	$1.18
Home health care services	1.49	2.01	$0.96	$1.31
Offices of physicians- dentists- and other he	1.82	2.00	$0.96	$1.31
Other ambulatory health care services	2.12	2.00	$0.72	$1.11
Hospitals	2.00	2.07	$0.89	$1.20
Nursing and residential care facilities	1.43	2.10	$1.00	$1.26
Child day care services	1.24	1.79	$0.64	$1.13
Social assistance- except child day care serv	1.29	2.14	$0.96	$1.19
Performing arts companies	1.31	2.23	$1.07	$1.33
Spectator sports	1.49	2.09	$1.05	$1.36
Independent artists- writers- and performers	2.32	2.01	$0.83	$1.22
Promoters of performing arts and sports and a	1.39	1.70	$0.61	$1.19
Museums- historical sites- zoos- and parks	2.00	2.43	$1.32	$1.39
Fitness and recreational sports centers	1.31	2.09	$0.91	$1.22
Bowling centers	1.36	1.84	$0.62	$1.09
Other amusement- gambling- and recreation ind	1.51	1.79	$0.61	$1.11
Hotels and motels- including casino hotels	1.55	1.80	$0.64	$1.13
Other accommodations	1.67	1.94	$0.55	$1.00
Food services and drinking places	1.34	1.93	$0.64	$1.01
Car washes	1.33	1.87	$0.62	$1.11
Automotive repair and maintenance- except car	1.54	1.76	$0.65	$1.01
Electronic equipment repair and maintenance	1.81	1.73	$0.57	$1.02
Commercial machinery repair and maintenance	1.69	1.66	$0.55	$1.00
Household goods repair and maintenance	1.59	1.35	$0.28	$0.80
Personal care services	1.34	1.86	$0.65	$1.12
Death care services	1.54	1.85	$0.81	$1.14
Drycleaning and laundry services	1.34	1.95	$0.85	$1.21
Other personal services	2.03	1.77	$0.39	$0.89
Religious organizations	1.65	1.81	$0.45	$1.01
Grantmaking and giving and social advocacy or	1.60	2.83	$1.59	$1.44

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California 2004 IMPLAN Multipliers by Industry

IMPLAN Sector Name	Employ-ment Multiplier	Output Multiplier	Total Labor Income per $ Output	Total Value Added per $ Output
Civic- social- professional and similar organ	1.49	2.94	$1.81	$1.52
Private households	1.07	2.01	$1.33	$1.60
Federal electric utilities	Na	0.00	$0.00	$0.00
Other Federal Government enterprises	1.29	2.47	$1.57	$1.53
State and local government passenger transit	1.90	3.21	$1.76	$1.23
State and local government electric utilities	2.83	1.49	$0.40	$0.99
Other State and local government enterprises	2.70	1.88	$0.63	$1.04
Noncomparable imports	Na	0.00	$0.00	$0.00
Scrap	Na	0.00	$0.00	$0.00
Used and secondhand goods	Na	0.00	$0.00	$0.00
State & Local Education	1.30	1.83	$1.10	$1.49
State & Local Non-Education	1.63	1.95	$1.25	$1.56
Federal Military	1.56	1.91	$1.20	$1.54
Federal Non-Military	2.17	1.89	$1.18	$1.53
Rest of the world adjustment to final uses	Na	0.00	$0.00	$0.00
Inventory valuation adjustment	Na	1.00	$0.00	$1.00
Owner-occupied dwellings	Na	1.24	$0.09	$0.96