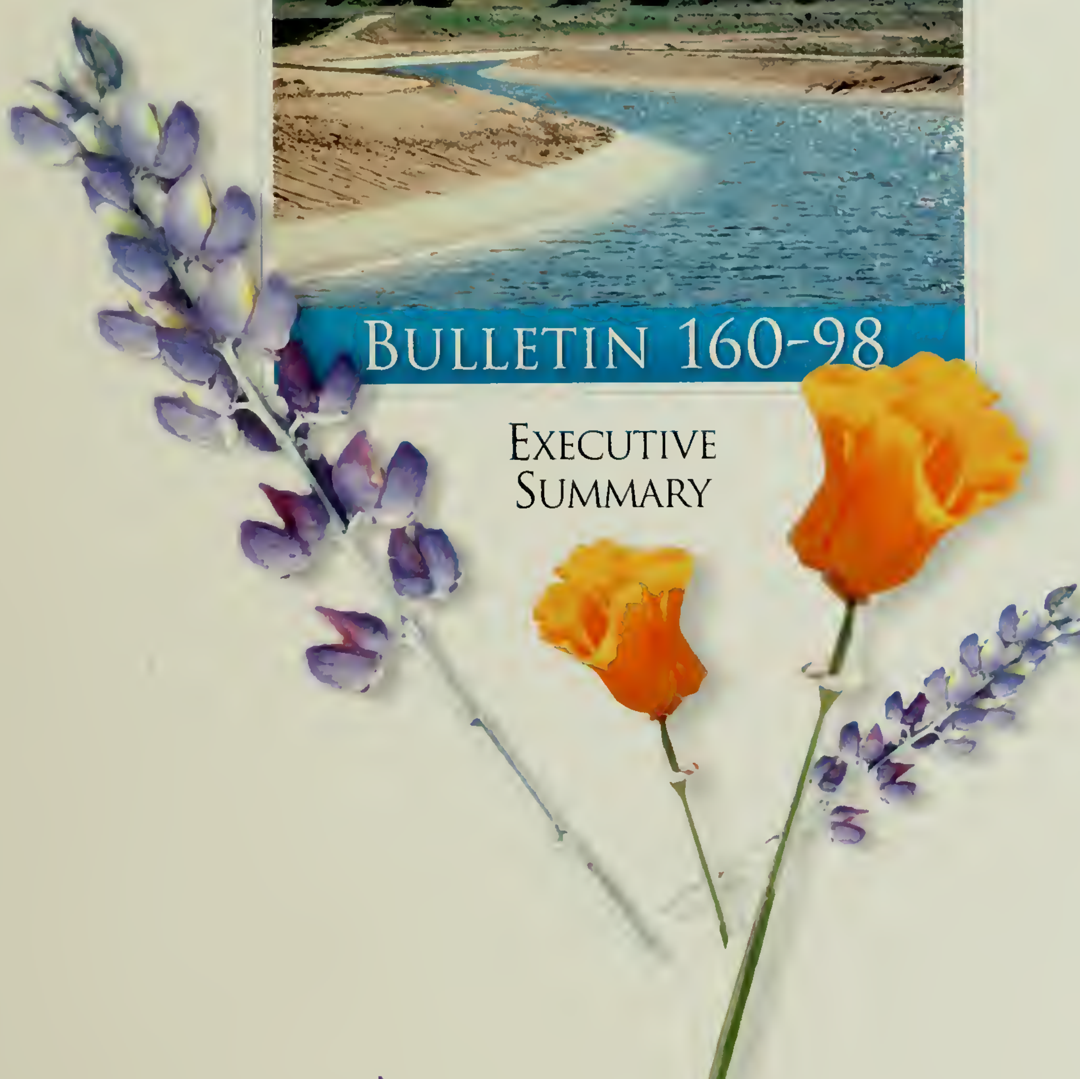
THE CALIFORNIA WATER PLAN UPDATE

BULLETIN 160-98



EXECUTIVE SUMMARY

California Water Plan Update Bulletin 160-98

Executive Summary

November 1998

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Governor

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Foreword

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In 1957, the Department published Bulletin 3, the *California Water Plan*. Bulletin 3 was followed by the Bulletin 160 series, published six times between 1966 and 1993, updating the *California Water Plan*. A 1991 amendment to the California Water Code directed the Department to update the plan every five years. Bulletin 160-98 is the latest in the series. The Bulletin 160 series assesses California's water needs and evaluates water supplies, to quantify the gap between future water demands and water supplies. The series presents a statewide overview of current water management activities and provides water managers with a framework for making decisions.

In response to public comments on the last update, Bulletin 160-93, this 1998 update evaluates water management options that could improve California's water supply reliability. Water management options being planned by local agencies form the building blocks for evaluations performed for each of the State's ten major hydrologic regions. Local options are integrated into a statewide overview that illustrates potential progress in reducing the State's expected future water shortages.

When the previous water plan update was released, California was just emerging from a six-year drought. This update follows the largest and most extensive flood disaster in California's history, the January 1997 floods. These two hydrologic events fittingly illustrate the complexity of water management in the State.

The Department appreciates the assistance provided by the Bulletin 160-98 public advisory committee, which met with the Department over a three-year period as the Bulletin was being prepared. The Department also appreciates the assistance provided by the many local water agencies who furnished information about their planned water management activities.

David N. Kennedy
Director

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The California Water Commission serves as a policy advisory body to the Director of the Department of Water Resources on all California water resources matters. The nine-member citizen commission provides a water resources forum for the people of the State, acts as a liaison between the legislative and executive branches of State government, and coordinates federal, State, and local water resources efforts.

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Executive Summary

Introduction

In 1957, the Department published Bulletin 3, the *California Water Plan.* Bulletin 3 was followed by the Bulletin 160 series, published six times between 1966 and 1993, updating the *California Water Plan.* A 1991 amendment to the California Water Code directed the Department to update the plan every five years. Bulletin 160-98 is the latest in the series.

The Bulletin 160 series assesses California's agricultural, environmental, and urban water needs and evaluates water supplies, in order to quantify the gap between future water demands and the corresponding water supplies. The series presents a statewide overview of current water management activities and provides water managers with a framework for making water resources decisions.

The Department's Bulletin 160 series quantifies only California's managed or dedicated water uses—urban, agricultural, and environmental uses. Unmanaged uses, such as the precipitation consumed by native plants, are not quantified.

While the basic scope of the Department's water plan updates has remained unchanged, each update has taken a distinct approach to water resources planning, reflecting issues or concerns at the time of its publication. In response to public comments on the last update, Bulletin 160-93, the 1998 update evaluates water management actions that could be implemented to improve California's water supply reliability. Bulletin 160-93 analyzed 2020 agricultural, environmental, and urban water demands in considerable detail. These demands, together with water supply information, have been updated for the 1998 Bulletin, which also uses a

2020 planning horizon. However, much of Bulletin 160-98 is devoted to identifying and analyzing options for improving water supply reliability. Water managemenr options available to, and being considered by, local agencies form the building blocks of evaluations prepared for each of the State's ten major hydrologic regions. (Water supplies provided by local agencies represent about 70 percent of California's developed water supplies.) These potential local options are integrated with options that are statewide in scope, such as the CALFED Bay-Delta program, to create a statewide evaluation.

The statewide evaluation represents a snapshot, at an appraisal level of detail, of how actions planned by California water managers could reduce the gap between supplies and demands. The evaluation does not present potential measures to reduce all shortages statewide to zero in year 2020. Such an approach would not reflect economic realities and current planning by local agencies. Not all areas of the State and not all water users can afford to reduce drought year shortages to zero. Bulletin 160-98 focuses on compiling those options that appear to have a reasonable chance of being implemented by water suppliers, to illustrate potential progress in reducing the State's future shortages.

Overview of California's Water Needs

Bulletin 160-98 estimates that California's water shortages at a 1995 level of development are 1.6 maf in average water years, and 5.1 maf in drought years. (As described later in the Bulletin, shortages represent the difference between water supplies and water demands.) The magnitude of shortages shown for drought conditions in the base year reflects the cutbacks in supply experienced by California water users during the recent six-year drought. Bulletin 160-98 forecasts increased shortages by 2020—2.4 maf in an average water year and 6.2 maf in drought years. The water management options identified as likely to be implemented could reduce those shortages to 0.2 maf in average water years and 2.7 maf in drought years.

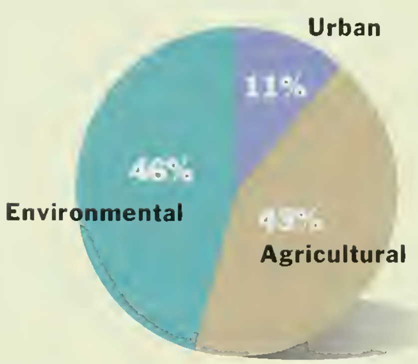
Population growth is expected to drive the State's increased water demands. To put California's population into perspective, about one of every eight U.S.

Summary of Key Statistics

Shown below for quick reference are some key statistics presented in the Bulletin. Water use information is based on average water year conditions. The details behind the statistics are discussed in Chapter ES4.

	1995	*2020 Forecast*	*Change*
Population (million)	32.1	47.5	+15.4
Irrigated crops (million acres)	9.5	9.2	-0.3
Urban water use (maf)	8.8	12.0	+3.2
Agricultural water use (maf)	33.8	31.5	-2.3
Environmental water use (maf)	36.9	37.0	+0.1

1995



2020

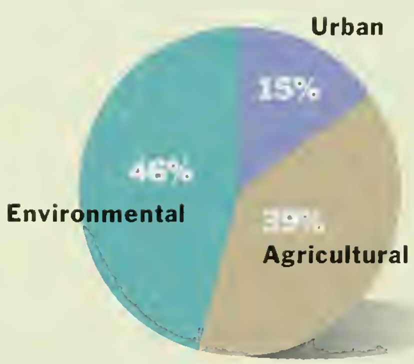
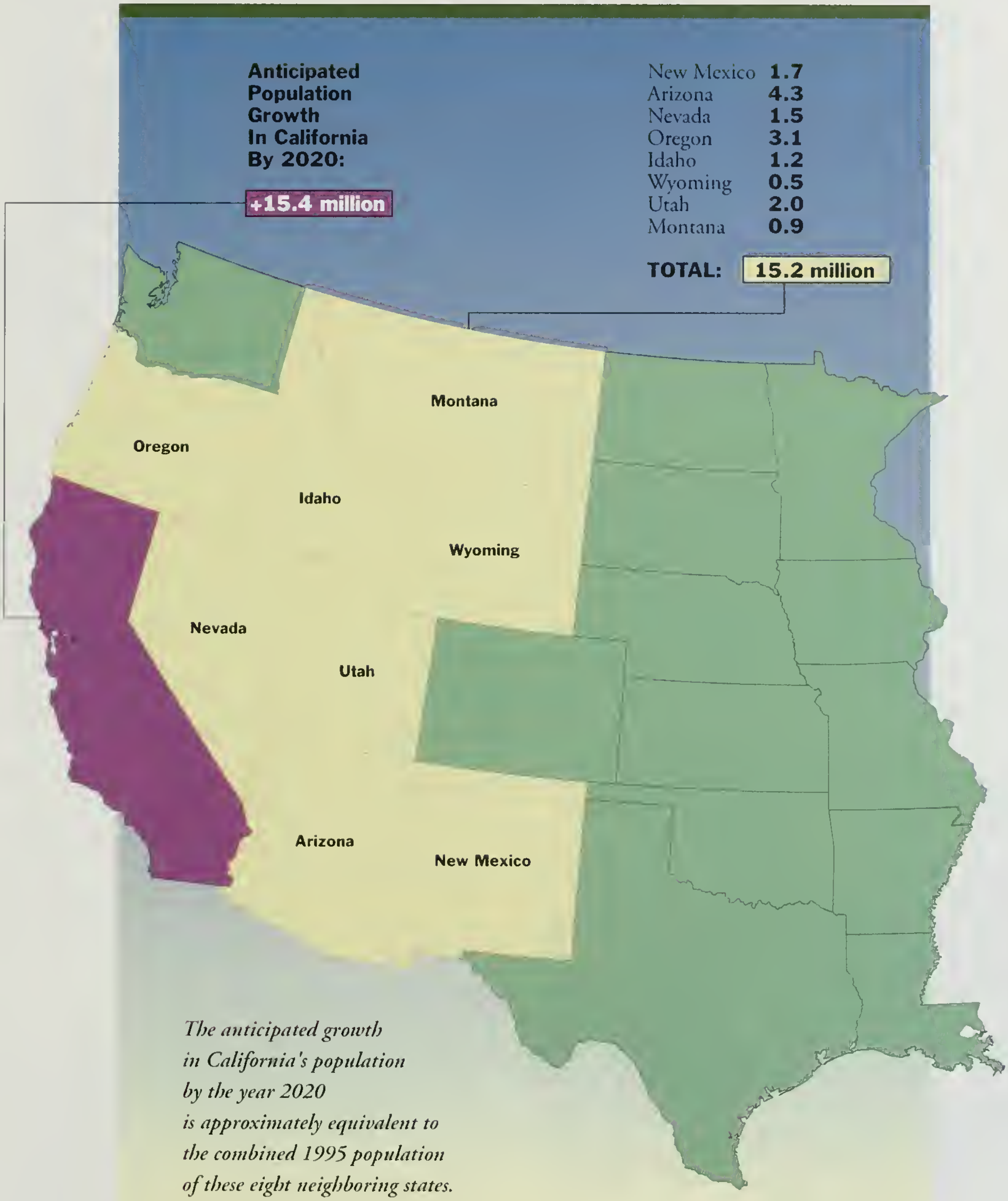


FIGURE ES1-1

California's Expected Population Growth Versus Neighboring States' Populations



The anticipated growth in California's population by the year 2020 is approximately equivalent to the combined 1995 population of these eight neighboring states.

residents now lives in California. During the time period covered in the Bulletin (the 25 years from 1995 to 2020), California's population is forecast to increase by more than 15 million people, the equivalent of adding the present populations of Arizona, Nevada, Oregon, Idaho, Montana, Wyoming, New Mexico, and Utah to California, as shown in Figure ES1-1. Today, four of the nation's 15 largest cities (Los Angeles, San Diego, San Jose, and San Francisco) are located in the State.

The sidebar on page ES1-2 summarizes key statistics developed later in the Bulletin.

Bulletin 160-98 Hydrologic Regions

Figure ES1-2 shows California's ten hydrologic regions, corresponding to the State's major drainage basins. The Department subdivides the State into regions for planning purposes. The largest planning unit is the hydrologic region, a unit used extensively in this Bulletin. The next level of delineation below hydrologic regions is the planning subarea. Some of the Bulletin's regional water management evaluations discuss information at the PSA level. The smallest study unit used by the Department is the detailed analysis unit. California is divided into 278 DAUs. Most of the Departments' Bulletin 160 analyses begin at the DAU level, and the results are aggregated into hydrologic regions for presentation.

Agreements reached in the 1994 Bay-Delta Accord were widely hailed as a truce in California's water wars. The approach taken in the Bay-Delta exemplifies some hallmarks of today's water management activities—increased participation by local governments and other stakeholders in statewide water management issues, and significant efforts to carry out ecosystem restoration actions.

Changes Since the Last California Water Plan Update

The last *California Water Plan* update, Bulletin 160-93, was published in 1994 and used 1990-level information to represent base year water supply and demand conditions. At that time, California had recently emerged from the six-year drought and Bay-Delta issues were in a state of flux. Bulletin 160-98 uses 1995-level information to represent base year conditions, including new (interim) Bay-Delta standards.

Changes in Sacramento-San Joaquin River Delta conditions are a major difference between the two bulletins. Bulletin 160-93 was based on State Water Resources Control Board Decision 1485 regulatory conditions in the Delta, and used a range of 1 to 3 maf for unspecified future environmental water needs—a range that reflected uncertainties associated with Bay-Delta water needs and Endangered Species Act implementation. Bulletin 160-98 uses SWRCB's Order WR 95-6 as the base condition for Bay-Delta operations, and describes proposed CALFED actions for the Bay-Delta.

Bulletin 160-93 was the first *California Water Plan* update to examine the demand/supply balance for drought water years as well as for average water years, a response to water shortages experienced during the then-recent drought. Bulletin 160-98 retains the drought year analysis and also considers the other end of the hydrologic spectrum—flooding. Traditionally, water supply has been the dominant focus of the water plan updates. In response to the January 1997 flooding in Northern and Central California, Bulletin 160-98 highlights common areas in water supply and flood control planning and operations and emphasizes the benefits of multipurpose facilities.

Changes in Response to Bulletin 160-93 Public Comments

Other changes between the two reports resulted from public comments on Bulletin 160-93. The dominant public comment on Bulletin 160-93 was that it should show how to reduce the gap between existing supplies and future demands, in addition to making supply and demand forecasts. Bulletin 160-98 addresses that comment by presenting a compilation of local agencies' planning efforts together with potential water management options that are statewide in scope. Local agencies' plans form the base for this effort, since it is local water purveyors who have the

FIGURE ES1-2

California's Hydrologic Regions

California's Hydrologic Regions

North Coast	Klamath River and Lost River Basins, and all basins draining into the Pacific Ocean from the Oregon stateline southerly through the Russian River Basin.
San Francisco Bay	Basins draining into San Francisco, San Pablo, and Suisun Bays, and into Sacramento River downstream from Collinsville; western Contra Costa County; and basins directly tributary to the Pacific Ocean below the Russian River watershed to the southern boundary of the Pescadero Creek Basin.
Central Coast	Basins draining into the Pacific Ocean below the Pescadero Creek watershed to the southeastern boundary of Rincon Creek Basin in western Ventura County.
South Coast	Basins draining into the Pacific Ocean from the southeastern boundary of Rincon Creek Basin to the Mexican boundary.
Sacramento River	Basins draining into the Sacramento River system in the Central Valley (including the Pit River drainage), from the Oregon border south through the American River drainage basin.
San Joaquin River	Basins draining into the San Joaquin River system, from the Cosumnes River basin on the north through the southern boundary of the San Joaquin River watershed.
Tulare Lake	The closed drainage basin at the south end of the San Joaquin Valley, south of the San Joaquin River watershed, encompassing basins draining to Kern Lakebed, Tulare Lakebed, and Buena Vista Lakebed.
North Lahontan	Basins east of the Sierra Nevada crest, and west of the Nevada stateline, from the Oregon border south to the southern boundary of the Walker River watershed.
South Lahontan	The closed drainage basins east of the Sierra Nevada crest, south of the Walker River watershed, northeast of the Transverse Ranges, north of the Colorado River Region. The main basins are the Owens and the Mojave River Basins.
Colorado River	Basins south and east of the South Coast and South Lahontan regions; areas that drain into the Colorado River, the Salton Sea, and other closed basins north of the Mexican border.

ultimate responsibility for meeting their service areas' needs.

Bulletin 160-98 excludes groundwater overdraft from the Bulletin's base year water supply estimate and is therefore the first water plan update to show an average water year shortage in its base year. (Both of the bulletins excluded future groundwater overdraft from future water supply estimates.) About 1.5 maf of the 1.6 maf base year shortage is attributable to groundwater overdraft.

Finally, Bulletin 160-98 uses applied water data, rather than the net water amounts historically used in the water plan series. This change was made in response to public comments that net water data were more difficult to understand than applied water data. This concept is explained in Chapter ES3.

Changes in Future Demand/Shortage Forecasts

Bulletin 160-93 used a planning horizon of 1990-2020. Bulletin 160-98 uses a planning horizon of 1995-2020. Bulletin 160-98 uses the 2020 planning horizon because no major data changes occurred between the two reports that would justify extending the planning horizon. Urban water demands depend heavily on population forecasts—the next U.S. Census will not be conducted until 2000.

The water plan series uses population forecasts from the Department of Finance. DOF reduced its 2020 forecast for California in the period between Bulletin 160-93 and Bulletin 160-98. The reduction reflects the impacts of the economic recession in California in the early 1990s. California experienced a record negative net domestic migration then, as more people moved out of the State than moved in. This reduction in the population forecast translates to a reduction in forecasted urban water use in Bulletin 160-98.

The 2020 forecasted agricultural water demands increased from Bulletin 160-93 to Bulletin 160-98, even though the forecasted crop acreage decreased slightly. This increase resulted from elimination of the "other" category of water use shown in Bulletin 160-93, which included conveyance losses. For Bulletin 160-98, water in the "other" category was reallocated back to the major water use categories to simplify information presentation. Most of the conveyance losses are associated with agricultural water use. Combining the "other" category into the major water use categories most affected the agricultural water demand forecast. When conveyance losses are factored out of the Bulletin 160-98 forecast, agricultural water use decreases between Bulletin 160-93 and Bulletin 160-98.

Bulletin 160-93 was the first water plan update to quantify environmental water use, recognizing the importance of the water that is dedicated to environmental purposes for maintaining those resources and that this water is unavailable for future development for other purposes. As illustrated earlier, the environmental sector is California's largest water using sector. Bulletin 160-98 uses the same definition and quantification procedure for environmental water use as did Bulletin 160-93.

The 2020 environmental water demand forecast increased substantially from Bulletin 160-93 to Bulletin 160-98. This increase results from implementation of the Bay-Delta Accord, inclusion of additional wild and scenic river flows, and increased instream flow requirements.

The shortage shown in Bulletin 160-98 is similar in magnitude to the low end of the shortage range reported in Bulletin 160-93. The treatment of forecasted Bay-Delta environmental water demands accounts for much of the difference. The range of potential future environmental water demands of 1 to 3 maf used in Bulletin 160-93 was added to that Bulletin's base environmental water demand forecast, rather than being evaluated through operations studies, because Bay-Delta regulatory assumptions could not be determined then. This conservative approach yielded higher demands than operations studies would have provided.

Preparation of Bulletin 160-98

Although the water plan updates are published only every five years, the Department continuously compiles and analyzes the annual data used to prepare them. After publication of Bulletin 160-93 in 1994, the remainder of that year was devoted to finishing data evaluation deferred during the Bulletin's production. Work on Bulletin 160-98 began in 1995. A citizens' advisory committee with more than 30 members, representing a wide range of interests, was established to assist the Department in its preparation of the next water plan update. The advisory committee met with Department staff 17 times during Bulletin 160-98 preparation, and in August 1997 reviewed an administrative draft that preceded release of the public review draft at the end of January 1998. The review period for the public draft extended through mid-April 1998, during which time public meetings were held and presentations were made to interested parties. The draft was also made available on the World Wide Web. Over 4,000 copies of the public review draft were distributed.

Public Comments on Draft

The Department received over 200 comment letters on the draft and additional comments from public meetings. Many comments were provided by local agencies whose facilities and projects are described in the public draft, and dealt with edits or corrections regarding those facilities or projects. Another major class of comments dealt with policy, conceptual, or analytical subjects. Many of these comments were influenced by discussions taking place in the CALFED Bay-Delta program and reflected the commenters' positions on CALFED issues. For example, proponents of CALFED's no conveyance improvements alternative generally expressed opposition to Bulletin 160-98's exclusion of groundwater overdraft as a supply, because this approach increases overall statewide shortages. The Department received positive public comments on Bulletin 160-93 when it excluded groundwater overdraft as a supply for the first time, and also received positive comments on its treatment of overdraft for Bulletin 160-98. Often, public comments conflicted with one another. For example, environmental organizations frequently stated that the Bulletin should include more future water conservation, while water purveyors frequently stated that levels assumed in the Bulletin were overly optimistic. Some comments suggested that the Bulletin's future water demands could be reduced by raising water prices, while others felt that the forecasted demands were too low and did not take into account future needs of California's population and agricultural economy. Likewise, some comments expressed philosophical opposition to constructing more reservoirs in California, while others emphasized the need for more storage and flood control reservoirs. The Department considered these comments in the context of the Bulletin's goal of accurately reflecting actions that water purveyors statewide would be reasonably likely to implement by year 2020.

Some comments suggested that Bulletin 160-98 (or the Department, or the State of California) advocate or express a vision on a variety of subjects—including State-funded water supply development, sustainable development, nonpoint source pollution, flood control, food production security, mandatory water pricing, and greater use of desalting (by entities other than the commenter). Such an approach is outside the scope of the Department's water plan update series. The role of the Bulletin 160 series is to evaluate present and future water supplies and demands given current social/economic policies, and to evaluate progress in meeting California's future water needs. As appropriate, the Bulletin discusses how other factors such as flood control may relate to water supply planning.

To develop 2020-level conditions, the Department makes a fundamental assumption that today's conditions—facilities, programs, water use patterns, and other factors—are the basis for predicting the future. (And, as one commenter correctly pointed out, Bulletin 160-98 also assumes that California's climate will remain unchanged over the Bulletin's 25-year planning horizon.) This approach differs distinctly from the approach of establishing a desired future goal or vision, and then preparing a plan that would implement that goal or vision. Such a plan would require broad public acceptance that simply does not exist today.

Many of the advocacy or vision comments described above are also not within the Department's jurisdiction or the jurisdiction of other State agencies. For example, the Department's role in developing water supply for local agencies is limited to fulfilling its State Water Project contractual obligations. (The Department may provide financial assistance to local agencies for various water management programs as authorized under bond measures enacted by the Legislature and approved by the voters.) The Department has no regulatory authority to mandate how local water agencies price their water supplies, or to require that local agencies adopt one type of water management option over another. Comments such as those suggesting that the Department plan for control of nonpoint source pollution or food production address the jurisdictional areas of other State agencies.

The subject of flood control merits special mention because of the direct relationship between operation of water supply projects and flood control projects. The purpose of the water plan update series is to evaluate water supplies, but those supplies can be affected by flood control actions such as increasing the amount of reservoir storage dedicated to flood control purposes. With memories of the disastrous January 1997 floods still fresh in people's minds, some commenters recommended that Bulletin 160-98 devote more attention to flood control needs, such as floodplain mapping programs, that are not directly related to water supply considerations. The 1997 *Final Report of the Governor's Flood Emergency Action Team* describes recommended actions to be taken based on the damages experienced in January 1997. Sections of that report are referenced throughout the Bulletin. Bulletin 160-98 emphasizes the interaction between water supply and flood control planning, and points out the benefits associated with multipurpose water projects.

As discussed in the following section, the Department received a number of comments requesting that Bulletin 160-98 quantify future water supply uncertainties associated with ongoing programs or regulatory actions, such as the CALFED Bay-Delta program, Federal Energy Regulatory Commission hydroelectric plant relicensing, and Endangered Species Act listings. Text has been added that quantifies those actions for which data are available.

The Department received some comments that could not be incorporated in Bulletin 160-98 because they suggested substantial changes in the scope or content of the Bulletin that could not be addressed before the Bulletin's due date to the Legislature, or suggested changes for the next update of the water plan. The scope of Bulletin 160-98 was established in coordination with the Bulletin's advisory committee in 1995, just as the scope of the next plan update (five years hence) will be established early in the process of preparing that update. The Department will consider these long-term comments when work begins on the next update.

Works in Progress and Uncertainties

The descriptions of major California water management activities provided in the Bulletin are generally current through July 1998. There are several pending activities that could be characterized as works in progress, including the CALFED Bay-Delta program and Colorado River water use discussions. For programs such as these, the Bulletin describes their current status and potential impacts, if known, on future water supplies. There are uncertainties associated with the outcomes of these activities, just as there are with any process that is evaluated in mid-course.

As noted at the beginning of this chapter, each water plan update focused on issues or concerns of special interest at the time of its publication. As an example of this focus, Bulletin 160-83 was the last water plan update to review water use for hydropower generation. No major changes have occurred since the late 1970s/early 1980s, when high energy prices and favorable tax treatment for renewable energy spurred a boom in small hydropower development. Today, uncertainties about water supply and water use associated with hydropower production are increasing, with the 1998 initiation of deregulation for California investor-owned power utilities and the prospect of FERC relicensing of several powerplants on major Sierra Nevada rivers between 2000 and 2010. Although there is presently little information available on which to base forecasts of resultant changes in water supplies, more information is likely to be available for the next water plan update.

Colorado River interstate issues are a new addition to a statewide water picture largely dominated by Delta and Central Valley Project Improvement Act issues in the recent past. Achieving a solution to California's need to reduce its use of Colorado River water to the State's basic apportionment (a reduction of as much as 900 taf from historical uses) requires consensus among California's local agencies that use the river's water, as well as concurrence in the plan by the other basin states.

Presentation of Data in Bulletin 160-98

Water budget and related data are tabulated by hydrologic region throughout the Bulletin. The statewide totals in these tables are generally presented as rounded values. As a result, individual table entries will not necessarily sum exactly to the rounded totals.

In the Chapter ES5 water budget appendices, regional water use/supply totals and shortages are not rounded. Individual table entries may not sum exactly to the reported totals due to rounding of individual entries for presentation purposes.

2

Executive Summary

Current Events in California Water Management

This chapter highlights some significant infrastructure and institutional changes that have occurred since the publication of Bulletin 160-93, and reviews the status of selected high-profile programs.

Facilities

A common theme in previous *California Water Plan* updates has been the need to respond to the State's continually increasing population. Population growth brings with it the need for new or expanded infrastructure. California's water purveyors have made significant infrastructure improvements—including reservoirs, conveyance facilities, recycling and desalting facilities, and structural environmental restoration projects—since publication of the last *California Water Plan* update.

In 1998, Contra Costa Water District completed its 100 taf Los Vaqueros Reservoir, improving water quality and providing emergency storage for its service area. Metropolitan Water District of Southern California is constructing its Eastside Reservoir in Riverside County. When completed in 1999, this 800 taf reservoir will nearly double the region's existing surface storage capacity and will provide increased terminal storage for SWP and Colorado River supplies. Eastside Reservoir would provide the entire region with a six-month emergency supply after an earthquake or other disaster and would also provide water supply for drought protection and peak summer demands.

California's increasing population is a driving factor in future water management planning.

TABLE ES2-1

Major Water Conveyance Facilities Since 1992

Facility	*Constructing Agency*	*Status*	*Length (miles)*	*Maximum Capacity (cfs)*
Coastal Branch Aqueduct	Department of Water Resources	completed 1997	100	100
Eastside Reservoir Pipeline	Metropolitan Water District of Southern California	completed 1997	8	1,000
East Branch Enlargement	Department of Water Resources	completed 1996	100	2,880
Mojave River Pipeline	Mojave Water Agency	started 1997	71	94
Old River Pipelines (Los Vaqueros Project)	Contra Costa Water District	completed 1997	20	400
East Branch Extension	Department of Water Resources	started 1998	14	104
Inland Feeder Project	Metropolitan Water District of Southern California	started 1997	44	1,000
Morongo Basin Pipeline	Mojave Water Agency	completed 1994	71	100
New Melones Water Conveyance Project	Stockton East Water District and Central San Joaquin Water Conservation District	completed 1993	21	500

Several major conveyance projects were completed or began construction since the last water plan update. For example, the Department's Coastal Aqueduct, completed in 1997, now carries SWP water to San Luis Obispo and Santa Barbara Counties. Mojave Water Agency recently completed a major conveyance facility (71 miles long) and is constructing another of similar length to import surface water to its service area to alleviate longstanding groundwater overdraft problems. Large conveyance projects under construction or recently completed are listed in Table ES2-1.

Water recycling and desalting are becoming larger components of existing and potential future water supplies, especially for urban areas. Bulletin 160-98 estimates 1995-level total statewide water recycling to be 485 taf/yr, considerably higher than the Bulletin 160-93 total water recycling estimate of 384 taf/yr. Groundwater recharge and agricultural and landscape irrigation constitute the greatest uses of recycled water in the State. As advanced treatment technologies become more cost-effective, and as public acceptance increases, augmentation of surface water supplies may become another application for recycled water. The San Diego water repurification program, a proposed project to repurify 16 taf/yr of wastewater, would be the first example of highly treated recycled water being discharged directly into a surface reservoir.

Today, California has more than 150 desalting plants producing fresh water from brackish groundwater, municipal and industrial wastewater, and seawater. The capacity of these plants totals about 66 taf/yr; seawater desalting capacity accounts for only 8 taf/yr of total capacity. Most existing plants are small (less than 1 taf/yr) and have been constructed in coastal communities with limited water supplies. The Santa

DWR's extension of the Coastal Branch to serve San Luis Obispo and Santa Barbara Counties provides an imported surface water supply that can help reduce overdraft of coastal groundwater basins.

Barbara desalting plant, with a capacity of 7.5 taf/yr, is the largest seawater desalting plant in California. The plant was constructed during the 1987-92 drought and is now on long-term standby. In 1997, the Marina Coast Water District completed construction on a reverse osmosis seawater desalting plant. This $2.5 million plant produces about 340 af/yr.

Many large-scale environmental restoration projects and programs are being implemented. Facilities associated with these programs include the United States Bureau of Reclamation's Shasta Dam Temperature Control Device, USBR's Red Bluff Diversion Dam Research Pumping Plant, and many fish screens or fish passage improvements at local agency and privately-owned diversions. Financial assistance provided by programs such as CVPIA's anadromous fish restoration program and CALFED's Category III program has resulted in a major expansion of local agency screening and fish passage projects. Table ES2-2 lists some of the largest examples of recently completed structural fishery restoration projects.

Several more large fish screen facilities are nearing the final phases of design or construction, including diversions on the Sacramento River at the Glenn-Colusa Irrigation District, Reclamation District 108 near Grimes, Reclamation District 1004 near Princeton, the Princeton-Codora-Glenn Irrigation District and Provident Irrigation District consolidated diversion, and others. Construction of GCID's Hamilton City Pumping Plant screen began in spring 1998. This $70 million project will minimize fish losses near the pumping plant and will maximize GCID's ability to meet its water supply delivery obligations. Reclamation District 108 began construction in 1997

USBR is evaluating the fishery impacts of different types of pump diversions to the Tehama-Colusa Canal. One alternative for improving fish passage at Red Bluff Diversion Dam would be to leave the dam's gates in the raised position and use a pumping plant to make TCC diversions. The research plant contains three pumps—one helical pump and two Archimedes screw pumps (right side of photo).

TABLE ES2-2

Large Structural Fishery Restoration Projects

Project	*Owner*	*Description*
Shasta Dam Temperature Control Device	USBR	An approximately $83 million modification to the dam's outlet works to allow temperature-selective releases of water through the dam's powerplant was completed in 1997.
Red Bluff Diversion Dam Research Pumping Plant	USBR	A $40 million experimental facility to evaluate fishery impacts of different types of pumps diverting Sacramento River water into the Tehama-Colusa and Corning Canals was constructed in 1995.
Butte Creek fish passage	Western Canal Water District and others	A multi-component project to improve fish passage by removing small irrigation diversion dams from the creek. By 1998, five diversion dams will have been removed.
Maxwell Irrigation District fish screen	Maxwell ID	An 80 cfs diversion on the Sacramento River was screened in 1994.
Pelger Mutual Water Company fish screen	PMWC	A 60 cfs diversion on the Sacramento River was screened in 1994.

on a new $10 million fish screen. The project, located at the district's Wilkens Slough diversion, will protect migrating winter-run chinook salmon. The district anticipates completing the project by the 1999 irrigation season. Reclamation District 1004 began construction of its $8 million fish screen in 1998. In addition to a fish screen, the project includes relocation of the Princeton Pumping Plant and conveyance facilities. In 1998, the Princeton-Codora-Glenn and Provident Irrigation Districts are expected to complete construction of an $11 million fish screen and pump consolidation project. The 600 cfs project eliminates three unscreened diversions.

Legislation

Proposition 204

In 1996, California voters approved Proposition 204, the Safe, Clean, Reliable Water Supply Act. The act authorized the issuance of $995 million in general obligation bonds to finance water and environmental restoration programs throughout the State. Approximately $600 million of these bonds would provide the State share of costs for projects benefitting the Bay-Delta and its watershed, including $390 million of this amount to implement CALFED's ecosystem restoration program for the Bay-Delta. These latter funds would be available after final federal and State environmental documents are certified and a cost-sharing agreement is executed between the federal and State governments. Table ES2-3 summarizes all programs authorized for Proposition 204 funding.

Proposition 218

Voter approval of Proposition 218 in November 1996 changed the procedure used by local government agencies for increasing fees, charges, and benefit assessments. Benefit assessments, fees, and charges that are imposed as an "incident of property ownership" are now subject to a majority public vote. Proposition 218 defines "assessments" as any levy or charge on real property for a special benefit conferred to the real property, including special assessments, benefit assessments, and maintenance assessments. Proposition 218 further defines "fee" or "charge" as any levy (other than an ad valorem tax, special tax, or assessment), which is imposed by an agency upon a parcel or upon a person as an incident of property ownership, including a user fee or charge for a property-related service.

Although there are many tests to determine if a fee or charge is subject to the provisions of Proposition 218, the most significant one is whether the agency has relied upon any parcel map for the imposition of the fee or charge. There is currently uncertainty in the interpretation of Proposition 218 requirements, especially as they relate to certain water-related fees and charges. From one point of view, Proposition 218 could be interpreted as a comprehensive approach to regulate all forms of agency revenue sources. This broad interpretation would include all fees and charges for services provided to real property. Types of water-related charges and fees that may be affected by Proposition 218's requirements include meter charges, acreage-based irrigation charges, and standby charges. Additional legislation or judicial interpretation may be needed to clarify the application of Proposition 218 to fees and charges used by water agencies. Several water industry groups are working on proposals for clarifying legislation. To date, there has been one water-related legislative clarification of Proposition 218. A 1997 statute clarified that assessments imposed by water districts and earmarked for bond repayment are not subject to the proposition's voter approval requirements.

Municipalities and special districts are beginning to seek voter approval of assessments as required by Proposition 218. Many assessments to fund existing programs have been receiving voter approval. There is at least one example, however, of a water agency whose proposed assessment was not approved. Monterey County Water Resources Agency did not receive voter approval for an assessment to support existing programs—groundwater quality monitoring, water conservation, and nitrate management outreach—funded by water standby charges. Examples of MCWRA's proposed assessment charges were $1.67 per irrigated acre for agricultural land use and $2.26 per parcel for single-family dwellings.

MTBE

Detection of methyl tertiary butyl ether in water supplies soon after it was approved for use as an air pollution-reducing additive in gasoline has raised concerns about its mobility in the environment. Legislation enacted in 1997 included several provisions dealing with MTBE regulation, monitoring, and studies. One provision required the Department of Health Services to establish a primary (health-based) drinking water standard for MTBE by July 1999, and a secondary (taste and odor) drinking water standard by July 1998.

MTBE can be detected by taste at very low concentrations, hence the early requirement for a secondary drinking water standard.

Safe Drinking Water Act

The Safe Drinking Water Act, administered by the U.S. Environmental Protection Agency in coordination with the states, is the chief federal regulatory legislation dealing with drinking water quality. The 104th Congress reauthorized and made significant changes to the SDWA, which had last been reauthorized in 1986. Major changes included:

- Establishing a drinking water state revolving loan fund, to be administered by states in a manner similar to the existing Clean Water Act State Revolving Fund. Loans would be made available to public water systems to help them comply with national primary drinking water regulations and to upgrade water treatment systems.
- The standard-setting process for drinking water contaminants established in the 1986 amendments was changed from a requirement that EPA adopt standards for a set number of contaminants on a fixed schedule to a process based on risk assessment and cost/benefit analysis. The 1996 amendments require EPA to publish (and periodically update) a list of contaminants not currently subject to national primary drinking water regulations, and to periodically determine whether to regulate at least five contaminants from that list, based on risk and benefit considerations.
- A requirement that states conduct vulnerability assessments in priority source water areas expanded existing source water quality protection provisions. States are authorized to establish voluntary, incentive-based source protection partnerships with local agencies. This activity may be funded from the new SRF.
- As a result of the 1996 amendments, EPA adopted a more ambitious schedule for promulgating the

TABLE ES2-3

Proposition 204 Funding Breakdown

Program	*Dollars (in millions)*
Delta Restoration	**193**
CVPIA State share	93
Category III State share	60
Delta levee rehabilitation	25
South Delta barriers	10
Delta recreation	2
CALFED administration	3
Clean Water and Water Recycling	**235**
State Revolving Fund Clean Water Act loans	80
Clean Water Act grants to small communities	30
Loans for water recycling projects	60
Loans for drainage treatment and management projects	30
Delta tributary watershed rehabilitation grants and loans	15
Seawater intrusion loans	10
Lake Tahoe water quality improvements	10
Water Supply Reliability	**117**
Feasibility investigations for specified programs	10
Water conservation and groundwater recharge loans	30
Small water project loans and grants, rural counties	25
Sacramento Valley water management and habitat improvement	25
River parkway program	27
CALFED Bay-Delta Ecosystem Restoration Program	**390**
Flood Control Subventions	**60**
Total	**995**

Disinfectant/Disinfection By-Products Rule and the Enhanced Surface Water Treatment Rule. The first phase of the D/DBP Rule is proposed to take effect in late 1998, as is an interim ESWTR. More stringent versions of both rules are proposed to follow in 2002.

Reclamation, Recycling, and Water Conservation Act of 1996

This act amended Title 16 of PL 102-575 by authorizing federal cost-sharing in additional wastewater recycling projects. (PL 102-575 had authorized federal cost-sharing in specified recycling projects.) The additional California projects are shown below, along with the nonfederal sponsors identified in the statute.

- North San Diego County area water recycling project (San Elijo Joint Powers Authority, Leucadia County Water District, City of Carlsbad, Olivenhain Municipal Water District)
- Calleguas Municipal Water District recycling project (CMWD)
- Watsonville area water recycling project (City of Watsonville)
- Pasadena reclaimed water project (City of Pasadena)
- Phase 1 of the Orange County regional water reclamation project (Orange County Water District and County Sanitation Districts of Orange County)
- Hi-Desert Water District wastewater collection and reuse facility (HDWD)
- Mission Basin brackish groundwater desalting demonstration project (City of Oceanside)
- Effluent treatment for the Sanitation Districts of Los Angeles County with the City of Long Beach (Water Replenishment District of Southern California, OCWD)
- San Joaquin area water recycling and reuse project (San Joaquin County, City of Tracy)

Federal cost-sharing in these projects is authorized at a maximum of 25 percent for project construction and federal contributions for each project are capped at $20 million. Funds are not to be appropriated for project construction until after a feasibility study and cost-sharing agreement are completed. Federal cost-sharing may not be used for operations and maintenance.

The act also authorizes the Department of Interior to cost-share up to 50 percent (planning and design) in a Long Beach desalination research and development project. Local sponsors are the City of Long Beach, Central Basin Municipal Water District, and MWDSC.

Water Desalination Act of 1996

This act authorizes DOI to cost-share in non-federal desalting projects at levels of 25 percent or 50 percent (for projects which are not otherwise feasible unless a federal contribution is provided). Cost-shared actions can be research, studies, demonstration projects, or development projects. The authorization provides $5 million per year for fiscal years 1997 through 2002 for research and studies, and $25 million per year for demonstration and development projects. The act requires DOI to investigate at least three different types of desalting technology and to report research findings to Congress.

Major Water Management Issues and Programs

Bay-Delta Accord and CALFED

Representatives from the California Water Policy Council, created to coordinate activities related to State long-term water policy, and the Federal Ecosystem Directorate, created to coordinate actions of federal agencies involved in Delta programs, signed a Framework Agreement for the Bay-Delta estuary in June 1994. Together, these agencies are known as CALFED. The Framework Agreement improved coordination and communication between State and federal agencies with resource management responsibilities in the estuary. It covered the water quality standards setting process; coordinated water project operations with requirements of water quality standards, endangered species laws, and CVPIA; and provided for cooperation in planning long-term solutions to problems affecting the estuary's major public values.

In December 1994 State and federal agencies, working with stakeholders, reached agreement on the "Principles for Agreement on Bay-Delta Standards Between the State of California and the Federal Government" (referred to as the Bay-Delta Accord) that would remain in effect for three years. Provisions of the Bay-Delta Accord covered water quality standard setting and water project operational constraints, ESA implementation and use of real-time monitoring data, and improvement of conditions not directly related to Delta outflow. Parties to the Accord committed to fund "non-flow Category III" measures at $60 million per year for the agreement's three-year term. The Accord was subsequently extended for a fourth year. An Operations Group composed of representatives from the State and federal water projects and the other CALFED agencies was established to coordinate project operations. Stakeholders from water agencies, and environmental and fishery groups participate in Operations Group meetings.

Water Quality Standard Setting. SWRCB adopted a water quality control plan for the Bay-Delta in May 1995, incorporating agreements reached in the Accord. In June 1995, SWRCB adopted Order WR 95-6, an interim order amending terms and conditions of SWRCB's Decision 1485 and the SWP's and Central Valley Project's water right permits to resolve inconsistencies with D-1485 requirements and the projects' voluntary implementation of Accord standards. The interim order will expire when a water right decision allocating final responsibilities for meeting the 1995 objectives is adopted, or on December 31, 1998, whichever comes first. SWRCB released a revised draft EIR for implementing the water quality control plan in 1998, and intends to issue a water right decision implementing the order by the end of 1998. The DEIR has eight flow alternatives:

(1) SWP and CVP Responsible for D-1485 Flow Objectives
(2) SWP and CVP Responsible for 1995 Bay-Delta Water Quality Control Plan Flow Objectives
(3) Water Right Priority Alternative—the CVP's Friant Unit is assumed to be an in-basin project.
(4) Water Right Priority Alternative—the CVP's Friant Unit is assumed to be an export project.
(5) Watershed Alternative—monthly average flow requirements are established for major watersheds based on Delta outflow and Vernalis flow objectives and the watersheds' average unimpaired flow. The parties responsible for providing the required flows are water users with storage in foothill reservoirs that control downstream flow to the Delta, and water users with upstream reservoirs that have a cumulative capacity of at least 100 taf who use water primarily for consumptive uses.
(6) Recirculation Alternative—USBR is required to make releases from the Delta-Mendota Canal to meet the Vernalis flow objectives.
(7) San Joaquin Basin Negotiated Agreement—San Joaquin Basin water right holders' responsibility to meet the plan objectives is based on an agreement titled "Letter of Intent among Export Interests and San Joaquin River Interests to Resolve San Joaquin River Issues Related to Protection of Bay-Delta Environmental Resources."
(8) San Joaquin Basin Negotiated Agreement—Vernalis flow objectives are replaced by target flows contained in the agreement.

CALFED Long-Term Solution-Finding Process for Bay-Delta. The June 1994 Framework Agreement called for a State-federal process to develop long-term solutions to Bay-Delta problems related to fish and wildlife, water supply reliability, natural disasters, and water quality. The CALFED program is managed by an interagency team under the policy direction of CALFED member agencies, with public input provided by the Bay-Delta Advisory Council. BDAC is a 31-member advisory panel representing California's agricultural, environmental, urban, business, fishing, and other interests who have a stake in the long-term solution to Bay-Delta problems.

The CALFED program's first phase identified problems and goals for the Bay-Delta, and developed a range of alternatives for long-term solutions. This phase concluded with a September 1996 report identifying three broad solutions, each of which included

Actions funded by the Category III program include fish screening, fish passage improvements, habitat acquisition, and control of non-native invasive species. The zebra mussel has caused millions of dollars of increased operations and maintenance costs to Great Lakes water users. Preventing the mussels' spread is a priority in invasive species management.

CALFED's Ecosystem Restoration Program calls for extensive creation of new habitat in the Delta. Construction of setback levees would allow restoration of riparian and riverine aquatic habitats, benefitting fish and wildlife.

a range of water storage options, a system for conveying water, and some programs that were common to all alternatives. The second phase consisted of preparing a programmatic EIR/EIS covering three main alternatives for conveyance of water across the Delta—an existing system alternative, a through-Delta alternative, and a dual Delta conveyance alternative. The first public review draft of the PEIR/PEIS was released in March 1998. CALFED expects to issue a second draft PEIR/PEIS by the end of 1998. The revised draft would identify CALFED's draft preferred alternative.

The third phase would involve staged implementation of the preferred alternative over a time period of several decades and will require site-specific environmental documents. Current plans are for an initial implementation period of 7 to 10 years, during which only common program elements would be implemented (water conservation measures, ecosystem restoration, levee improvements). Any conveyance or storage facilities would be constructed in a later phase of implementation.

ESA Administration. The December 1994 Bay-Delta Accord established several principles governing ESA administration in the Bay-Delta during the agreement's term.

- The Accord is intended to improve habitat conditions in the Bay-Delta to avoid the need for additional species listings during the agreement's term. If additional listings do become necessary, the federal government will acquire any additional water supply needed for those species by buying water from willing sellers.
- There is intended to be no additional water cost to the CVP and SWP resulting from compliance with biological opinion incidental take provisions for presently listed species. The CALFED Operations Group is to develop operational flexibility by adjusting export limits.
- Real-time monitoring is to be used to the extent possible to make decisions regarding operational flexibility. CALFED commits to devote significant resources to implement real-time monitoring.

Colorado River

A major issue facing California is its use of Colorado River water in excess of the amount apportioned to it by the existing body of statutes, court decisions, and agreements controlling use of the water supply among the seven basin states. California's basic apportionment of river water is 4.4 maf of consumptive use per year (plus a share of surplus flows, when available), as compared to its present consumptive use of up to 5.3 maf/yr. California's use has historically exceeded the basic apportionment because California has been able to divert and use Arizona's and Nevada's unused apportionments, and to divert surplus water. With completion of the Central Arizona Project and the 1996 enactment of groundwater banking legislation, Arizona projects that it will use almost all of its 2.8 maf apportionment for the first time in 1998. Nevada is projected to use about 280 taf of its 300 taf apportionment in 1998.

California local agencies, working through the Colorado River Board of California, have been developing a proposal for discussion with the other basin states to illustrate how, over time, California would reduce its use to the basic apportionment of 4.4 maf/yr. Drafts of the proposal, known as the draft Colorado River Board 4.4 Plan, have been shared with the other states. Efforts are being made to reach intrastate consensus on the plan in 1998. As Bulletin 160-98 goes to press, the most current version of the draft plan is the December 1997 version.

As formulated, the draft plan would be implemented in two phases. The first phase (between the present and 2010 or 2015) would entail implementing already identified measures such as water conservation and transfers to reduce California's Colorado River water use to about 4.6 to 4.7 maf/yr. The second phase would implement additional measures to reduce California's use to its basic annual 4.4 maf apportionment in those years when neither surplus water nor other states' unused apportionments were available. One of the fundamental assumptions made in the plan is that MWDSC's Colorado River Aqueduct will be kept full by making water transfers from agricultural users in the Colorado River Region to urban water users in the South Coast Region.

Actions included in the first phase were: core water transfers such as the existing Imperial Irrigation District/MWDSC agreement and the proposed Imperial Irrigation District/San Diego County Water Authority transfer; seepage recovery from unlined sections of the All American and Coachella Canals; drought year water transfers similar to the Palo Verde Irrigation District/MWDSC pilot project; groundwater banking in Arizona; and conjunctive use of groundwater in areas such as the Coachella Valley. The draft plan recognizes that transfers of conserved water must be evaluated in the context of preserving the Salton Sea's environmental resources, and also that plan elements must address environmental impacts on the lower Colorado River and its listed species.

Other actions to occur as part of the first phase would include implementation of the San Luis Rey Indian water rights settlement authorized in PL 100-675 and implementation of measures to administer agricultural water entitlements within the first three priorities of the Seven Party Agreement. An important element of the draft CRB 4.4 Plan is the concept that existing reservoir operating criteria be changed by USBR to make optimum use of the river's runoff and available basin storage capacity. California agencies developed new proposed operating criteria that are included in the draft CRB 4.4 Plan. The draft plan contemplates that changes in operating criteria would be part of both the first and second phases. The other basin states have been cautious in their reaction to California's proposals for reservoir reoperation, and have suggested, for example, that new criteria should not be implemented until California has prepared the environmental documents and executed the agreements that would be needed to begin implementation of the draft CRB 4.4 Plan.

The second phase of the draft CRB 4.4 Plan would include additional average year and drought year water transfers. Specifics on these transfers would be developed during the first phase of plan implementation. Other components of the second phase would include further transfers of conserved agricultural water to the South Coast and further work on reservoir operating criteria. Implementation of some elements of phase two of the plan may extend beyond the Bulletin 160-98 planning horizon.

Recent ESA Listings

Since publication of Bulletin 160-93, there has been action on federal listing of several fish species having statewide water management significance. In August 1997, the National Marine Fisheries Service listed two coastal steelhead populations as threatened (from the Russian River south to Soquel Creek, and from the Pajaro River south to the Santa Maria River), and one population as endangered (from the Santa Maria River south to Malibu Creek). NMFS deferred listing decisions for six months for other California populations—from the Elk River in Oregon to the Trinity River in California, from Redwood Creek to

USBR's Parker Dam on the Colorado River impounds Lake Havasu. At this location, the Colorado River forms the stateline between California and Arizona. MWDSC's Colorado River Aqueduct and the Central Arizona Project divert from Lake Havasu.

the Gualala River, and in the Central Valley—due to scientific disagreement about the sufficiency and accuracy of the data available for listing determinations. In March 1998, NMFS listed the Central Valley population as threatened, and deferred listing of the two north coast populations in favor of working with California and Oregon on state conservation plans.

Also in 1997, NMFS listed the Southern Oregon/Northern California coast evolutionarily-significant unit of coho salmon as threatened. In 1996, NMFS listed coho salmon in the central coast ESU (from Punta Gorda in Humboldt County south to the San Lorenzo River) as threatened.

In 1998, NMFS proposed several runs of chinook salmon for listing—the spring-run in the Central Valley ESU as endangered, the fall and late-fall runs in the Central Valley ESU as threatened, and the spring and fall runs in the Oregon/California coastal ESU as threatened. (The spring-run chinook salmon has been listed as a candidate species under the California ESA.) NMFS expects to make its decision on listing in 1999.

USFWS proposed in 1994 to list a resident Delta fish species, the Sacramento River splittail, but a congressional moratorium on listing of new species prevented USFWS from working on the proposal until 1996. USFWS again proposed to list splittail in 1996, but received significant public comments on new scientific information for splittail. The extended public comment period ended July 1998. USFWS is expected to make a decision after reviewing comments.

USFWS has also listed or proposed for listing species whose limited range would result in localized water management impacts. For example, the red legged frog, found primarily in the Central Coast area, was listed as threatened in 1996. Another example is the Santa Ana sucker, found in the Santa Ana River, proposed for listing in 1998.

January 1997 Central Valley Floods

The January 1997 flood event was notable for its sustained rainfall intensity, the volume of floodwater, and the extent of the storm pattern—from the Oregon border down to the southern end of the Sierra. Over a three day period, warm moist winds from the southwest blew over the Sierra Nevada, pouring over 30 inches of rain on watersheds already saturated by one of the wettest Decembers on record. In many major river systems, flood control dams reduced flood flows by half or more, saving lives and significantly reducing property damage. However, in some areas, leveed flood control systems were overwhelmed, causing approximately $2 billion in damages.

Most of the large reservoirs in Northern California were full or nearly full within the first days in January. Several Sacramento Valley reservoirs—including Shasta, Oroville, and New Bullards Bar—experienced record inflows during the January 1997 flood event. American River inflow to Folsom Reservoir was similar to the amount recorded during the February 1986 flood. Levees of the federal Sacramento River Flood Control Project (see sidebar) sustained moderate to heavy damage, including two major levee breaks (one near the town of Arboga) and several relief cuts. Flooding in the Marysville-Yuba City area resulted in 35,000 people being evacuated from the Marysville area and 75,000 people being evacuated downstream in Sutter County.

The volume of runoff exceeded the flood control capability of New Don Pedro Reservoir on the Tuolumne River and Millerton Lake on the Upper San Joaquin River. While the peak flood release from New Don Pedro Dam was less than half the peak Tuolumne River inflow of 120,000 cfs, it was more than six times the downstream channel's flow restrictions of 9,000 cfs. In all, 36 levee failures occurred along the San Joaquin River system, along with extensive damage related to high flows and inundation. Most of the damage occurred downstream of the Tuolumne River confluence.

The January 1997 floods demonstrated the need for increased Central Valley flood protection. The 1997 *Final Report of the Governor's Flood Emergency Action Team* identified many actions that could be taken to increase valley flood protection, including better emergency preparedness, floodplain management actions, levee system improvements, construction of new floodways, temporary storage of floodwaters on wildlife refuges, reoperation or enlargement of existing reservoirs to increase flood storage, and construction of new reservoirs.

The Sacramento River Flood Control Project's ability to provide protection for growing urban areas is the primary flood control issue facing the Sacramento Valley. Additional flood protection is needed in the Yuba River Basin, particularly in the greater Marysville-Yuba City area. Additional flood protection is also needed in the American River Basin for the Sacramento metropolitan area, as discussed in the accompanying sidebar. The 1997 FEAT report detailed several recommendations and possible actions for the Sacramento

The Sacramento metropolitan area has one of the lowest flood protection levels in the nation, for a community of its size. Without interim reoperation of Folsom Dam, the community is estimated to have only a 1-in-60 year level of protection. (With reoperation, the level of protection is 1-in-77 years). This photo shows the American River in January 1997, and the high-density urban development adjacent to the levee.

Valley, including new flood storage, enlarged flood bypasses, and increasing channel capacity through measures such as dredging and setback levees.

The primary flood control issue facing the San Joaquin River watershed is the lack of flood channel capacity. Channels and levees are generally designed for 50-year flood protection. Insufficient channel capacity is especially problematic in the lower San Joaquin River below the Merced River. At the lower end of the system, sediment deposition continues to raise the river bed and reduce channel capacity. Sediment deposition also promotes vegetation growth, thereby increasing channel roughness and further impeding flows. As urban development occurs on lands formerly used for agriculture, the need for higher levels of flood protection becomes more important. The 1997 FEAT report

American River Flood Protection

Following the floods of February 1986, the United States Army Corps of Engineers reanalyzed American River Basin hydrology and concluded that Folsom Dam did not provide an adequate level of flood protection to the downstream Sacramento area, significantly less than the 250-year protection estimated in the late 1940s when the dam was designed. The 977 taf reservoir has a normal winter flood control reservation of 400 taf (estimated to provide the Sacramento area with protection from a storm having a 1-in-60-year return period).

Three main flood protection alternatives have been evaluated by USACE. Two of the alternatives would increase flood control storage in Folsom, modify the dam's spillway and outlet works, and improve downstream levees. The third alternative would construct a detention dam at Auburn, with downstream levee improvements. USACE studies identified the detention dam as the plan that maximized national economic benefits. The State Reclamation Board endorsed the detention dam as the best long-term solution to reliably provide greater than 1-in-200 year flood protection.

The Central Valley's January 1997 flood disaster prompted another examination of American River hydrology. Based on that hydrologic review, the 1986 and 1997 floods are now considered to be about 60-year events. The 1997 flooding also triggered payback provisions of the Sacramento Area Flood Control Agency's agreement with USBR, under which USBR sets aside up to 270 taf of additional winter flood control space in Folsom. (This additional flood control space in the reservoir raises Sacramento's level of protection to about a 77-year event level.) Reoperation of Folsom for additional flood control resulted in a loss of supply to USBR. SAFCA and the federal government purchased 100 taf to offset the loss of supply—50 taf from Yuba County Water Agency, 35 taf from Placer County Water Agency, and 15 taf from GCID.

In 1998, the Reclamation Board restated its conclusion that the best long-term engineering solution to reliably provide greater than 1-in-200 year flood protection is to develop additional flood detention storage at Auburn. As an incremental measure to increase the level of flood protection, the Board also resolved to support SAFCA's plan for modifying Folsom Dam's outlets to increase flood protection to approximately a 1-in-110 year level. As of June 1998, SAFCA was seeking congressional authorization for USACE participation in Folsom Dam modifications and downstream levee enlargements.

The January 1997 flood disaster was the largest in the State's history. Flooding forced more than 120,000 people from their homes, and over 55,000 people were housed in temporary shelters. Nearly 300 square miles of agricultural land were flooded. Livestock and wildlife were trapped by the flooding.

detailed several recommendations and possible actions for the San Joaquin River watershed, including new flood storage, development restrictions and land acquisitions in the floodplain, and increasing channel capacity through measures such as dredging, setback levees, and improving bridge crossings.

CVPIA Implementation

CVPIA made significant changes to the CVP's legislative authorization, amending the project's purposes to place fish and wildlife mitigation and restoration on a par with water supply, and to place fish and wildlife enhancement on a par with power generation. Key areas of CVPIA implementation are summarized below. USBR and U.S. Fish and Wildlife Service released a draft programmatic EIS on CVPIA implementation for public review in November 1997. The draft PEIS describes, among other things, estimated water supply impacts of federal implementation of the act, and illustrates the consequences of different alternatives for fish and wildlife supplemental water acquisition. A final EIS is scheduled to be released in 1999.

Renewal of CVP Water Service Contracts. CVPIA prohibited execution of new CVP water service contracts (with minor exceptions), except for fish and wildlife purposes, until all of the many environmental restoration actions specified in the statute had been completed. The act also provided that existing long-term water service contracts be renewed for 25-year terms, as opposed to their previous 40-year terms. Only interim renewals (not more than three years) are allowed until the PEIS required by the act is completed. Beginning in October 1997, most existing long term contracts are subject to a monetary hammer clause encouraging early renewal. Renewed contracts will in-

Sacramento River Flood Control Project

Congress authorized the Sacramento River Flood Control Project in 1917 after a series of major Sacramento Valley floods in the late 1800s and early 1900s. The project was built with local, State, and federal funding. The project includes levees, overflow weirs, bypass channels, and channel enlargements. Overflow weirs allow excess water in the main river channel to flow into bypasses in the Sutter Basin and Yolo Basin. The bypass system was designed to carry 600,000 cfs of water past Sacramento—110,000 cfs in the Sacramento River through downtown Sacramento and West Sacramento, and the remainder in the Yolo Bypass. The system has worked exceedingly well over the years.

The capacity of the SRFCP was increased upon completion of Shasta Dam in 1945 and Folsom Dam in 1956. The Feather and Yuba River systems did not share in the SRFCP's flood control benefits; however, supplemental protection was provided by the completion of Oroville Dam on the Feather River in 1968 and New Bullards Bar Dam on the Yuba River in 1970. These are large multipurpose reservoirs in which flood control functions share space with water supply functions.

corporate new provisions required by CVPIA, such as tiered water pricing. Since USBR has not completed the PEIS, all contract renewals to date have been interim renewals. USBR has had more than 60 interim contract renewals from the date of enactment through 1996, representing over 1 maf/yr of supply.

Fish and Wildlife Restoration Actions. One of the most controversial elements of CVPIA implementation has been management of the 800 taf of CVP yield (see sidebar) dedicated by the act to fishery restoration purposes. This water is available for use on CVP controlled streams (river reaches downstream from the project's major storage facilities on the Sacramento River, American River, and Stanislaus River) and in the Bay-Delta.

The ambiguity of the statutory language and the use of dedicated water in the Bay-Delta Accord have generated many questions, including whether the water may be exported from the Delta after the water has been used for instream flow needs in upstream rivers, and if the water may be used for Bay-Delta purposes beyond Accord requirements. Initially, USBR and USFWS attempted to develop guidelines or criteria for its management. Subsequent to CALFED's creation, the CALFED Operations Group became a forum for attempting to resolve dedicated water. In November 1997, DOI released its final administrative proposal on management of the dedicated water. The proposal's release was subsequently challenged in legal action filed by some CVP water contractors.

A main purpose of the dedicated water is meeting the act's goal of doubling natural production of Central Valley anadromous fish populations (from their average 1967-91 levels) by year 2002. Release of water to the San Joaquin River from Friant Dam is excluded from this program. CVPIA authorizes USBR and USFWS to acquire additional, supplemental water from willing sellers to help achieve the doubling goal. CVPIA further allocates additional CVP water supply for instream use in the Trinity River by reducing the quantity of water which the project could otherwise divert, requiring that an instream flow of 340 taf/yr be maintained through water year 1996 while USFWS finishes a long-term instream flow study. (USFWS now recommends instream flows much greater than 340 taf/yr.)

CVPIA enumerates specific physical restoration measures that the federal government must complete for fishery and waterfowl habitat restoration. The largest completed measures are a temperature control device at Shasta Dam, at a cost of over $83 million, and a research pumping plant at Red Bluff Diversion Dam. CVPIA allocated part of the costs of some restoration measures to the State; the remaining costs are being paid by federal taxpayers and by CVP water and power contractors. Some of the smaller restoration actions include individual fish-screening projects that USBR and USFWS are cost-sharing with local agencies under the anadromous fish screening program.

CVPIA required USBR to impose a surcharge on CVP water and power contracts for deposit into a Restoration Fund created by the act. Monies deposited into the fund are appropriated by Congress to help fund CVPIA environmental restoration actions. The act authorizes appropriation of up to $50 million (1992 dollars) per year for the restoration actions. Annual deposits into the fund vary with water and power sales. CVPIA environmental restoration actions can be funded from the general federal treasury, as well as from the Restoration Fund.

Land Retirement Program. CVPIA authorized DOI to carry out an agricultural land retirement program for lands receiving CVP water. USBR published interim guidelines for administration of a pilot program, pending formal promulgation of rules and regulations. The federal guidelines were developed in

CVPIA's Dedicated Water

Section 3406(b)(2) describes the dedicated water as follows:

Upon enactment of this title dedicate and manage annually 800,000 acre-feet of Central Valley Project yield for the primary purpose of implementing the fish, wildlife, and habitat restoration purposes and measures authorized by this title; to assist the State of California in its efforts to protect the waters of the San Francisco Bay-San Joaquin Delta Estuary; and to help meet such obligations as may be legally imposed upon the Central Valley Project under State or Federal law following the date of enactment of this title, including but not limited to additional obligations under the federal Endangered Species Act. For the purpose of this section, the term "Central Valley Project yield" means the delivery capability of the Central Valley Project during the 1928-1934 drought period after fishery, water quality, and other flow and operational requirements imposed by terms and conditions existing in licenses, permits, and other agreements pertaining to the Central Valley Project under applicable State or Federal law existing at the time of enactment of this title have been met.

coordination with a State land retirement program established in 1992 under Water Code Section 14902 *et seq*. The State statute limited the retirement program to drainage-impaired lands. The State land retirement program has never been funded, and thus no State acquisitions have been made. By November 1997, the federal land retirement program had made one purchase—about 600 acres of drainage-impaired land in Westlands Water District that would be managed for wildlife habitat. Recently, USBR solicited proposals from landowners wishing to participate in the retirement program and received offers to sell lands amounting to 31,000 acres.

Other Programs and Reports. From a water supply standpoint, certain CVPIA-mandated reports are of special interest. USFWS has prepared several draft documents relating to estimated Central Valley environmental water needs and water management actions for the AFRP. The most recent draft of the AFRP was published in May 1997. In 1995, USBR released an appraisal-level least-cost CVP yield increase plan, required by the act to identify options for replacing the water supply dedicated to environmental purposes. Although the act directed that the plan be prepared, USBR was not required to implement it.

SWP Monterey Agreement Contract Amendments

The Monterey Agreement among the Department and SWP water contractors was signed in December 1994. This agreement set forth principles for making changes in SWP water supply contracts, which would then be implemented by an amendment (Monterey Amendment) to each contractor's SWP contract. The amendment has been offered to all SWP contractors. Those contractors that sign the amendment will receive the benefits of it, while those that do not will have their water supply contracts administered such that they will be unaffected by the amendment. As of July 1998, 26 of the 29 contractors had signed the amendment.

Changes to SWP Water Allocation Rules. The amendmenr states that during drought years project supplies are to be allocated proportionately on the basis of contractors' entitlements. The amendment allocates water to urban and agricultural purposes on an equal basis, deleting a previous initial supply reduction to agricultural contractors.

Permanent Sales of Entitlement. The amendment provides for transfer of up to 175 taf of entitlement from agricultural use. The first transfer made was relinquishment of 45 taf of entitlement (40,670 af from Kern County Water Agency, 4,330 af from Dudley Ridge Water District) back to the SWP, as part of the transfer of the Kern Water Bank property to these agencies. This relinquishment reduces the total SWP contractual commitment. The amendment provides for an additional 130 taf of existing agricultural entitlement to be sold on a permanent basis to urban contractors, on a willing buyer-willing seller basis.

Storing Water Outside a Contractor's Service Area; Transfers of Non-Project Water. This provision allows a contractor to store water in another agency's reservoir or groundwater basin. Examples include water storage programs with Semitropic Water Storage District, a member agency of Kern County Water Agency. The amendment also provides a mechanism for using SWP facilities to transport non-project water for SWP water contractors. (The Department uses other contractual arrangements for wheeling water for the CVP and for other non-SWP water users.)

Annual Turnback Pool. Prior to the amendment, water allocated to contractors that was not used during a year would revert to the SWP at the end of the year. No compensation was provided to the contractor for this water, and no other contractors could make use of these supplies during the year. The turnback pool is an internal SWP mechanism which provides for pooling potentially unused supplies early in the year for purchase by other SWP contractors at a set price. If neither the SWP nor individual SWP contractors wish to use water placed into the pool, that water may then be sold to entities that are not SWP contractors.

Other Operational Changes. The amendment established a procedure to transfer ownership of the Department's KWB property to KCWA and Dudley Ridge Water District. The amendment allows contractors repaying costs of constructing the Castaic and Perris terminal reservoirs to increase their control and management of a portion of the storage capacity of each reservoir, to optimize the operation of local and SWP facilities. This is expected, for example, to improve dry year supplies for MWDSC, Castaic Lake Water Agency, and Ventura County Flood Control and Water Conservation District.

Environmental Restoration Activities

Several major environmental restoration activities are ongoing throughout the State, in addition to the intensive effort focused on the Bay-Delta. Projects focused on fishery and habitat restoration on the State's three most important river systems—the Sacramento, San Joaquin, and Colorado Rivers—are described below, followed by a brief mention of restoration and mitigation projects in other watersheds.

Sacramento River System. The extensive structural environmental restoration actions being performed in the Sacramento River system were described earlier in this chapter. These actions include major projects such as USBR's Shasta Dam Temperature Control Device and research pumping plant at Red Bluff Diversion Dam, as well as fish screen installations at many of the larger irrigation diversions on the Sacramento River mainstem. Many more restoration actions are being planned, such as additional fish passage improvements on Butte and Clear Creeks and at Anderson-Cottonwood Irrigation District's diversion dam. Many of the actions on the river's mainstem were in response to the need to protect listed winter-run chinook salmon. Actions are also being taken to protect spring-run chinook salmon, a species proposed for listing under the federal ESA and a State candidate species.

In 1995, State legislation restricted future water development on Mill and Deer Creeks to protect spring run chinook salmon habitat. In addition, local landowners formed the Mill and Deer Creek Watershed Conservancies. The conservancies have begun a watershed planning and management process, with funding assistance from an EPA grant. The Department has participated with Mill Creek landowners in a test project to construct wells to provide groundwater supplies in lieu of creek diversions for irrigation during spring fish migration periods. A similar project is being negotiated with Deer Creek water users.

San Joaquin River System. One of the first overviews of San Joaquin River restoration needs was provided by the Resources Agency's 1995 San Joaquin River Management Program Plan, which evaluated potential actions on part of the river's mainstem and on the lower reaches of its main tributaries. Structural restoration work performed to date has focused largely on spawning gravel placement and related habitat improvements. Several other projects are now in planning, including replacement of Central California Irrigation District's Mendota Dam and a potential new fish hatchery on the Tuolumne River. Increased instream flows have been provided in the river system through SWRCB Order WR 95-6 requirements and through a FERC settlement agreement for the Tuolumne River.

The San Joaquin River Conservancy, a State agency charged with acquiring and managing public lands within the San Joaquin River Parkway, is working to expand lands preserved by the parkway. The parkway includes the San Joaquin River and about 5,900 acres of land on both sides of the river, extending about 22 miles from Friant Dam downstream to the Highway 99 crossing of the river. The parkway is planned as a riparian corridor with public access trails, boating access points, wildlife areas, and education areas. Approximately 1,900 acres are located in Madera County and 4,000 acres in Fresno County, of which approximately 1,600 acres are now in public ownership.

In February 1998, two large cylindrical fish screens were installed at one of the largest Delta diversions located on Sherman Island.

Lower Colorado River System. In 1995, DOI executed partnership agreements with California, Nevada, and Arizona to develop a multi-species conservation program for ESA-listed species and many non-listed, but sensitive, species within the 100-year floodplain of the lower Colorado River, from Glen Canyon Dam downstream to the Mexican border. In 1996, a joint participation agreement was executed to provide funding for the program. USFWS has designated the Lower Colorado River Multi-Species Conservation Program steering committee as an ecosystem conservation and recovery implementation team pursuant to ESA. The steering committee is composed of representatives from the three states, DOI, Indian tribes, water agencies, power agencies, environmental organizations, and others.

The conservation program will work toward recovery of listed and sensitive species while providing for current and future use of Colorado River water and power resources, and includes USBR's Colorado River operations and maintenance actions for the lower river. Over 100 species will be considered in the program, including the southwestern willow flycatcher, Yuma clapper rail, and four fish species listed under the federal ESA: Colorado squawfish, razorback sucker, humpback chub, and bonytail chub. Developing the program is estimated to take three years. Costs of program development and implementation of selected interim conservation measures, estimated at $4.5 million, are to be split equally between DOI and the non-federal partners.

USBR initiated a formal Section 7 consultation process with USFWS, who issued a five-year biological opinion on USBR operation and maintenance activities from Lake Mead to the southerly international boundary with Mexico in 1997. USBR has estimated that the cost of implementing the biological opinion's reasonable and prudent alternatives and measures could be as high as $26 million.

The steering committee is currently participating in funding several interim conservation measures. These include a razorback sucker recovery program at Lake Mojave, restoration of Deer Island near Parker, Arizona, and a "Bring Back the Natives" program sponsored by the National Fish and Wildlife Foundation.

Other Watersheds. Major environmental restoration activities are ongoing in other watersheds throughout the State, including the Russian and Kings Rivers and Lake Tahoe.

A Russian River Action Plan, prepared by Sonoma County Water Agency in 1997, provides a regional assessment of needs in the Russian River watershed and identifies fishery habitat restoration projects in need of funding. The SWRCB is promoting a coordinated Russian River fishery restoration plan.

Kings River Conservation District and the Kings River Water Association are cooperating with USACE in a feasibility study of Kings River fishery habitat improvements. One component of the study includes a new multi-level intake structure for the reservoir, to better manage downstream river temperatures. USACE is also implementing a related project to install a bypass pipe at the dam's powerplant so that releases can be made through the existing penstocks when the turbines are not in operation. This project will provide temperature control for the downstream trout fishery.

The Tahoe Regional Planning Agency, a bi-state agency created by Congress, has identified nearly $500 million in capital improvements needed to achieve environmental targets in the Lake Tahoe watershed. Federal, state, and local governments have invested nearly $90 million in erosion control, storm water drainage, stream zone restoration, public transit, and other capital projects. The U.S. Forest Service has implemented a watershed restoration program and a land acquisition program to prevent development of sensitive private lands. The State of Nevada approved a $20 million bond measure to perform erosion control and other measures on the east side of the lake. In California, Proposition 204 provides $10 million in bond funds for land acquisition and programs to control soil erosion, restore watersheds, and preserve environmentally sensitive lands.

Mitigation Projects. Significant habitat improvements are also resulting from land management or mitigation projects being carried out by water agencies. For example, the Department purchased much of Sherman and Twitchell Islands in the Delta, and is implementing management plans on them to control subsidence and soil erosion, while providing significant wetland and riparian habitat for wildlife. The plans also provide recreational opportunities such as walking trails and wildlife viewing.

CCWD established over 18,000 acres of preserve as part of its Los Vaqueros construction project. This land is being managed to protect listed species such as the San Joaquin kit fox. The project impacted 174 acres of valley oaks and 9 acres of alkali wetlands. To mitigate, CCWD is creating or enhancing 394 acres of woodland habitat and 49 acres of wetlands.

Kern Water Bank Authority set aside about 10,000 acres for habitat purposes as part of its 20,000-acre Kern Fan Element project. ESA listed species found in the project area include the kit fox, kangaroo rat, and blunt-nosed leopard lizard.

As part of its Eastside Reservoir project, MWDSC purchased 3,700 acres for the Nature Conservancy's Santa Rosa Plateau Ecological Reserve. MWDSC also purchased 9,000 acres for the Southwestern Riverside County Multi-Species Reserve, including lands around the reservoir, Lake Skinner, and the 2,500-acre Dr. Roy E. Shipley Reserve.

Behind Prado Dam in Riverside County, Orange County Water District operates 465 acres of constructed freshwater wetlands to reduce the nitrogen levels in the Santa Ana River. The river provides much of the county's coastal plain groundwater recharge. The Prado wetlands are home to several rare and endangered bird and waterfowl species. More than 226 acres are set aside as habitat for the endangered least Bell's vireo and southwestern willow flycatcher.

Implementation of Urban Water Conservation MOU

The 1991 *Memorandum of Understanding Regarding Urban Water Conservation in California* defined a set of urban best management practices and procedures for their implementation, and established a California Urban Water Conservation Council composed of MOU signatories (local water agencies, environmental groups, and other interested parties). More than 200 entities have signed the MOU. The CUWCC has monitored implementation of BMPs and reported progress annually to the SWRCB. The Council developed a plan providing for ongoing review of BMPs and potential BMPs. In late 1996, the Council initiated a review of the BMPs to clarify expectations for implementation and to develop an implementation evaluation methodology. Revised BMPs were adopted in 1997.

Implementation of Agricultural Efficient Water Management Practices MOU

The Agricultural Efficient Water Management Practices Act of 1990 (AB 3616) required the Department to establish an advisory committee to develop EWMPs for agricultural water use. Negotiations among agricultural water users, environmental interests, and governmental agencies on a memorandum of understanding to implement EWMPs were completed in 1996. The MOU established an Agricultural Water Management Council to oversee EWMP implementation, much like the organizational structure that exists for urban BMPs, and also provided a mechanism for its signatories to evaluate and endorse water management plans. By May 1998, the MOU had been signed by 31 agricultural water suppliers irrigating about 3 million acres of land, as well as by over 60 other entities.

Klamath River Fishery Issues

The primary water management issue in the interstate Klamath River basin is the restoration of fish populations that include listed species such as the Lost River and shortnose suckers, coho salmon, and steelhead trout. The Lost River sucker is native to Upper Klamath Lake and its tributaries, and the shortnose sucker is found in the Lost River, Clear Lake, Tule Lake, and Upper Klamath Lake. Both species spawn during the spring. Higher water levels in Upper Klamath Lake have been identified as an aid to recovery of these fisheries. Coho and steelhead were recently listed, and water supply implications will not be known until management plans are completed and recovery goals are established.

To address the need for greater certainty in project operations, USBR began preparing a long-term Klamath Project Operations Plan in 1995. Several issues have delayed completion of the long-term plan. USBR has issued an annual operations plan each year since 1995. The Klamath River Compact Commission is facilitating discussions on water management alternatives to address water supply needs. This three-member commission was established by an interstate compact ratified by Congress in 1957 to facilitate integrated management of interstate water resources. The KRCC, USBR, and both states are cooperatively developing water supply options. Members include a representative from the Department, the Director of the Oregon Water Resources Department, and a presidentially-appointed federal representative.

Truckee-Carson River System

The Truckee-Carson-Pyramid Lake Water Rights Settlement Act (Title II of Public Law No. 101-618) settled several water rights disputes affecting the waters of Lake Tahoe, the Truckee River, and the Carson River. Of most importance to California, the act made an interstate apportionment of these waters between the States of California and Nevada. (It was the first congressional apportionment since the Boulder Canyon Project Act of 1928.) The act addresses several other issues, including settlement of water supply disputes between the Pyramid Lake Paiute Tribe of Indians and other users of the Truckee and Carson Rivers. The act also addresses environmental concerns, such as recovery of listed fish species in Pyramid Lake.

Many of the act's provisions—including the interstate apportionment between California and Nevada—will not take effect until several conditions have been satisfied, including dismissal of specified lawsuits and negotiation and adoption of a Truckee River Operating Agreement. The act requires that a TROA be negotiated among DOI and California and Nevada, after consultation with other parties as may be designated by DOI or by the two states. The TROA addresses interstate water allocation and implements an agreement between Sierra Pacific Power Company and the United States which provides for storing water in upstream reservoirs for Pyramid Lake fish and emergency drought water supplies for the Reno-Sparks area. TROA negotiation has been ongoing since 1991. A draft TROA is analyzed in an EIS/EIR prepared by DOI. (The Department is the State lead agency for compliance with the requirements of CEQA.) The draft EIS/EIR was released for public review in 1998 and is expected to be completed in 1999.

City of Los Angeles' Water Supply from Owens Valley

In 1913, the City of Los Angeles began diverting water from Owens Valley through the Los Angeles Aqueduct. A second aqueduct, completed in 1970, increased the Los Angeles Department of Water and Power's capacity to divert both surface and groundwater from the Owens Valley. LADWP's water diversions have resulted in degradation of the valley's environmental resources. Recent issues have revolved around rewatering the lower Owens River and dust control on the Owens Lakebed.

Rewatering Lower Owens River. In 1972, Inyo County initially filed suit against the city, claiming that increased groundwater pumping from the second aqueduct was harming the Owens Valley environment. An EIR was subsequently prepared jointly by LADWP and the county, and in 1991 both parties executed a long-term water management agreement delineating how groundwater pumping and surface water diversions would be managed to avoid significant decreases in vegetation, water-dependent recreational uses, and wildlife habitat. Several agencies, organizations, and individuals challenged the adequacy of the EIR and were granted *amici curiae* status by the Court of Appeals, allowing them to enter in the EIR review process. Another agreement was subsequently executed in 1997, ending 25 years of litigation between Los Angeles and Inyo County.

The lower Owens River project, a major provision of the agreement, was developed to rewater approximately 60 miles of the Owens River channel from the LAA diversion downstream to Owens Lake. The project is also identified in the EIR as compensatory mitigation for impacts that occurred between 1970 and 1990 that were considered difficult to quantify or mitigate directly. Four significant physical features of the LORP and agreement are: provision of year-round flows in the lower Owens River (with a pumpback station just above the Owens River delta to return some of the water to the LAA), provision of flows past the pumpback station to create new wetlands in the Owens Lake delta, enhancement of off-river lakes and ponds, and development of a new 1,500-acre waterfowl habitat area.

The majority of planning work is expected to be completed by December 1998. Los Angeles will pay the costs of implementing the project, with the county repaying one half of the costs up to a maximum of $3.75 million. To date, the federal government has committed $300,000 for the design of the pumpback system. Congress has approved another $250,000 for planning and development work. LADWP and the county will jointly prepare an EIR on the LORP, with a draft expected by June 2000. Rewatering of the river channel will begin within 6 years after the pumpback system is completed.

Dust Control on Owens Lakebed. Owens Lake became a dry lakebed by 1929. On windy days, airborne particulates from the dry lakebed violate air quality standards in the southern Owens Valley. In 1997, the Great Basin Unified Air Pollution Control District ordered the City of Los Angeles to implement control measures at Owens Lake to mitigate the dust problems. Under the order, 8,400 acres of lakebed would be permanently flooded with a few inches of water, another 8,700 acres would be planted with grass and irrigated, and 5,300 acres would be covered with a 4 inch layer of gravel. This order, which was appealed by the city, could reduce the city's potential diversion by 50 taf/yr or about 15 percent of its supply.

In July 1998, a compromise was reached when

LADWP agreed to begin work at Owens Lake by 2001 and to ensure that federal clean air standards would be met by 2006. In turn, the APCD agreed to scale back the improvements sought in its 1997 order. Under this compromise, LADWP's dust-control strategy may include shallow flooding, vegetation planting, and gravel placement. The implementation schedule requires that 6,400 acres of lakebed be treated by the end of 2001. By the end of 2006, an additional 8,000 acres would be treated, plus any additional lakebed necessary to bring particulate counts into compliance with federal air quality standards. The plan hinges on final approval from the Los Angeles City Council, the APCD's board, and the State Air Resources Board.

Mono Basin

Mono Lake and its tributaries have been the subject of extensive litigation between the City of Los Angeles and environmental groups since the late 1970s. In 1983, the California Supreme Court ruled that SWRCB has authority to reexamine past water allocation decisions and the responsibility to protect public trust resources where feasible. SWRCB issued a final decision on Mono Lake (Decision 1631) in 1994. Amendments to LADWP's water right licenses are set forth in the order accompanying the decision.

The order sets instream flow requirements for fish in each of the four streams from which LADWP diverts water. The order also establishes water diversion criteria to protect wildlife and other environmental resources in the Mono Basin. These water diversion criteria prohibit export of water from Mono Basin until the lake level reaches 6,377 feet, and restrict Mono Basin water exports to allow the lake level to rise to an elevation of 6,391 feet in about 20 years. Once the water level of 6,391 feet is reached, it is expected that LADWP will be able to export about 31 taf of water per year from the basin. The order requires LADWP to prepare restoration plans for the four streams from which it diverts and to restore part of the waterfowl habitat which was lost due to lake level decline. In May 1997, parties to the restoration planning process presented a signed settlement on Mono Basin restoration to the SWRCB. If approved, the settlement would guide restoration activities and annual monitoring through 2014.

Key features of the stream restoration plans include restoring peak flows to Rush, Lee Vining, Walker, and Parker Creeks; reopening abandoned channels in Rush Creek; and developing a monitoring plan. One of the restoration actions required by SWRCB—bypassing sediment around LADWP diversion dams—was deferred for further analysis. The waterfowl habitat restoration plan proposes that a Mono Basin waterfowl habitat restoration foundation administer a $3.6 million trust established by LADWP. Five of the parties to the agreement would serve as initial members of the foundation. Activities would include annual monitoring, restoring open water habitat adjacent to the lake, and rewatering Mill Creek. LADWP would continue its brine shrimp productivity studies, open several channels on Rush Creek, and make its Mill Creek water rights available for rewatering Mill Creek, based on the recommendations of the foundation. The plans are being considered by SWRCB and a decision is expected at the end of 1998.

Salton Sea

The present day Salton Sea was formed in 1905, when Colorado River water flowed through a break in a canal that had been constructed along the U.S./Mexican border to divert the river's flow to agricultural lands in the Imperial Valley. Over the long term, the sea's elevation has gradually increased, going from a low on the order of -250 feet in the 1920s to its present level of about -226 feet. The Salton Sea is the largest lake located entirely within California, with a volume of about 7.5 maf at its present elevation of -226 feet. The sea occupies a closed drainage basin—if there were no inflows to maintain lake levels, its waters would evaporate. The sea receives over 1 maf annually of inflow, primarily from agricultural drainage. The largest sources of inflow (about 80 percent of the total) are the New and Alamo Rivers, which drain agricultural lands in the Mexicali and Imperial Valleys and flow into the sea's southern end.

The sea supports water-based recreational activities and has had a popular corvina fishery. During the 1950s, the highest per capita sport fishing catches in California were from the Salton Sea. Over the years, concerns about the sea's salinity have been voiced in the context of maintaining the recreational fishery that was established with introduced species able to tolerate high salinities.

The sea also provides important wintering habitat for many species of migratory waterfowl and shorebirds, including some species whose diets are based exclusively on the fish in the sea. Wetlands near the sea and adjoining cultivated agricultural lands offer the avian population a mix of habitat types and food sourc-

A natural-color satellite image of the Salton Sea (January 1998 Landsat 5). The irrigated areas in Imperial Valley are clearly visible to the south of the sea, as are the Algodones Dunes to the southeast. The City of Mexicali and irrigated acreage in the Mexicali Valley can also be seen.

es. An area at the sea's south end was established as a national wildlife refuge in 1930, although most of that area is now under water as a result of the sea's rising elevation. Some of the 380 bird species wintering in the area include pelicans, herons, egrets, cranes, cormorants, ibises, ducks, grebes, falcons, plovers, avocets, sandpipers, and gulls. The Salton Sea is considered to be a major stopover point for birds migrating on the Pacific flyway, and has one of the highest levels of bird diversity of refuges in the federal system.

Historically, salinity has been the water quality constituent of most concern at the sea. Present levels are about 44,000 mg/L TDS (seawater is about 35,000 mg/L TDS). This high level of salinity reflects long-term evaporation and concentration of salts found in its inflow. Selenium has been a more recent constituent of interest, due to its implications for aquatic species. Although selenium levels in the water column in the sea are less than the federal criterion of 5 *ug*/l, this concentration can be exceeded in seabed sediment and in influent agricultural drainage water. Agricultural drain flows also contribute significant nutrient loading to the sea, which supports large algal blooms at some times of the year.

Over the years, USBR and others have considered potential solutions to stabilize the sea's salinity and elevation. Most recently, the Salton Sea Authority (a joint powers authority consisting of Riverside and Imperial Counties, Imperial Irrigation District, and Coachella Valley Water District) and others have been performing appraisal level evaluations of some of the frequently suggested alternatives. Maintaining a viable Salton Sea has several water management implications. First will be the actions needed to stabilize the sea's salinity in the near-term, such as the authority's diking proposal. Eventually, a long-term solution will need to be developed. A wide range of costs has been mentioned for a long-term solution, including amounts in the billion-dollar range. Some of the possible long-term solutions suggested would entail constructing facilities in Mexico, bringing a greater level of complexity to their implementation.

Other water management programs in the region, such as proposals to transfer conserved agricultural water supplies, will have to be evaluated in terms of their impacts on the sea. Recent proposals to desalt water in the Alamo or New Rivers and to transport that water in the Colorado River Aqueduct to the South Coast for urban water supply have raised concerns about maintaining the sea's environmental productivity. Such proposals might be implemented as part of the second phase of CRB's draft 4.4 Plan.

Roadrunners are one of the bird species found year-round in the Salton Sea area.

Congressional legislation introduced in 1998 would authorize expenditure of federal funds for a multi-year study of the sea's resources and potential solutions for managing its salinity.

3

Executive Summary

Water Supplies

This chapter describes how water supplies are calculated and summarized within a water budget framework. A description of California's existing supplies–surface water, groundwater, recycled water, and desalted water–and how a portion of these supplies are reallocated through water marketing follows. This chapter concludes with a review of water quality considerations that influence how the State's water supplies are used.

Water Supply Calculation

Bulletin 160-98 calculates existing water supply and demand, then balances forecasted demand against existing supply and future water management options. The balance, or water budget, with existing supply is presented on a statewide basis in Chapter ES5 and on a regional basis in Appendix ES5A. The water budget with future water management options is also presented in Chapter ES5.

Definition of Bulletin 160 Water Supplies

The Bulletin 160 water budgets do not account for the State's entire water supply and use. In fact, less than one-third of the State's precipitation is quantified in the water budgets. Precipitation provides California with nearly 200 maf of total water supply in average years. Of this renewable supply, about 65 percent is depleted through evaporation and transpiration by trees and other plants. This large volume of water is excluded from the Bulletin 160 water supply

The SWP's California Aqueduct is the only conveyance facility that moves water from the Central Valley to Southern California.

Key Water Supply and Water Use Definitions

Chapters ES3 and ES4 introduce California's water supplies and urban, agricultural, and environmental water uses. Certain key concepts, defined below, provide an essential foundation for presenting and analyzing water supplies and water use.

Applied Water: The amount of water from any source needed to meet the demand of the user. It is the quantity of water delivered to any of the following locations:

- The intake to a city water system or factory.
- The farm headgate or other point of measurement.
- A managed wetland, either directly or by drainage flows.

For instream use, applied water is the quantity of stream flow dedicated to instream use (or reserved under federal or State wild and scenic rivers legislation) or to maintaining flow and water quality in the Bay-Delta pursuant to the SWRCB's Order WR 95-6.

Net Water: The amount of water needed in a water service area to meet all demands. It is the sum of evapotranspiration of applied water in an area, the irrecoverable losses from the distribution system, and agricultural return flow or treated urban wastewater leaving the area.

Irrecoverable Losses: The amount of water lost to a salt sink, lost by evapotranspiration, or lost by evaporation from a conveyance facility, drainage canal, or fringe areas.

Evapotranspiration: ET is the amount of water transpired (given off), retained in plant tissues, and evaporated from plant tissues and surrounding soil surfaces.

Evapotranspiration of Applied Water: ETAW is the portion of the total ET which is provided by applied irrigation water.

Depletion: The amount of water consumed within a service area that is no longer available as a source of supply. For agricultural and certain environmental (i.e., wetlands) water use, depletion is the sum of irrecoverable losses and the ETAW due to crops, wetland vegetation, and flooded water surfaces. For urban water use, depletion is the ETAW due to landscaping and gardens, wastewater effluent that flows to a salt sink, and incidental ET losses. For environmental instream use, depletion is the amount of dedicated flow that proceeds to a salt sink.

and water use calculations. The remaining 35 percent stays in the State's hydrologic system as runoff. (Figure ES3-1.)

Over 30 percent of the State's runoff is not explicitly designated for urban, agricultural, or environmental uses. This water is depleted from the State's hydrologic system as outflow to the Pacific Ocean or other salt sinks. (Some of this non-designated runoff is captured by reservoirs, but is later released for flood control.) Similar to precipitation depletions by vegetation, non-designated runoff is excluded from the Bulletin 160 water supply and water use calculations.

The State's remaining runoff is available as renewable water supply for urban, agricultural, and environmental uses in the Bulletin 160 water budgets. In addition to this supply, Bulletin 160 water budgets include a few supplies that are not generated by intrastate precipitation. These supplies include imports from the Colorado and Klamath Rivers and new supplies generated by water recycling and desalting.

Applied Water Methodology

Bulletin 160-98 water supplies are computed using applied water data. As defined in the sidebar, applied water refers to the amount of water from any source employed to meet the demand of the user. Previous editions of Bulletin 160 computed water supplies using net water data. Bulletin 160-98 switched from a net water methodology to an applied water methodology in response to public comments on Bulletin 160-93. Because applied water data are analogous to agency water delivery data, water supply data based on an applied water methodology are easier for local water agencies to review. Net water supply values are smaller than applied water supply values because they exclude that portion of demand met by reapplication of surface and groundwater supplies.

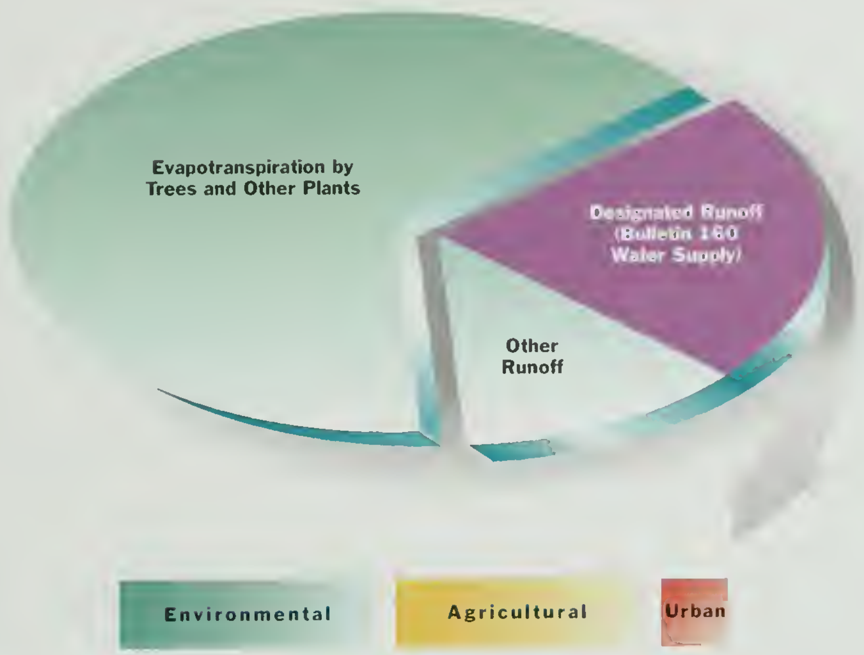
Reapplication can be a significant source of water in many hydrologic regions of California. An applied water budget explicitly accounts for this source. However, because of reapplication, applied water budgets do not translate directly into the supply of water needed to meet future demands. The approach used to compute the new water required to meet future demands with applied water budgets is presented in Chapter ES5.

Normalized Data

Water budget data used to represent the base planning year do not necessarily match the historical conditions observed in 1995. Instead, Bulletin 160-98's base year applied water budget data are developed

FIGURE ES3-1

Disposition of California's Average Annual Precipitation



from "normalized" water supply, land use, and water use data. Through the normalizing process, year-to-year fluctuations caused by weather and market abnormalities are removed from the data. For example, water year 1998 would greatly underestimate average annual water use, as rainfall through May and early June provided the necessary moisture needed to meet crop and landscape water demands. In most years, much of California would require applied water supplies during May and early June. The procedures used to normalize water supply and water use data are described in the sidebar on page ES3-4.

Water Supply Scenarios

California is subject to a wide range of hydrologic conditions and water supply variability. Knowledge of water supplies under a range of hydrologic conditions is necessary to evaluate reliability needs that water managers must meet. Two water supply scenarios—average year conditions and drought year conditions—were selected from among a spectrum of possible water supply conditions to represent variability in the regional and statewide water budgets.

The average year supply scenario represents the average annual supply of a system over a long planning horizon. Average year supplies from the CVP and SWP are defined by operations studies for a base (1995) level of development and for a future (2020) level of development. Project delivery capabilities are defined over a 73-year hydrologic sequence. For other water supply projects, historical data are normalized to represent average year conditions. For required environmental flows, average year supply is estimated for each of its components. Wild and scenic river flow is calculated from long-term average unimpaired flow data. Instream flow requirements are defined for an average year under specific agreements, water rights, court decisions, and congressional directives. Bay-Delta outflow requirements are estimated from operations studies.

For many local water agencies, and especially urban agencies, drought water year supply is the critical factor in planning for water supply reliability. Traditional drought planning often uses a design drought hydrology to characterize project operations under future conditions. For a planning region with the size and hydrologic complexity of California, selecting an appropriate statewide design drought presents a challenge. The 1990-91 water years were selected to represent the drought year supply scenario for Bulletin 160-98. (The 1990-91 water years were also used to represent the drought year scenario in Bulletin 160-93.)

Procedures for Normalizing Water Supply and Water Use Data

On the supply side, normalized water project delivery values are computed by averaging historical delivery data. Normalized "average year" project supplies are typically computed from 3 to 5 recent non-deficient water years. Normalized "drought year" project supplies are computed by averaging historical delivery data from 1990 and 1991. A notable exception to the above procedure is the development of normalized CVP and SWP project deliveries. Supplies from these projects are developed from operations studies rather than from historical data. Operations studies provide an average project delivery capability over a multi-year sequence of hydrology under SWRCB Order WR 95-6 Bay-Delta standards.

On the demand side, base year urban per capita water use data are normalized to account for factors such as residual effects of the 1987-92 drought. In any given year, urban landscape and agricultural irrigation requirements will vary with precipitation, temperature, and other factors. Base year water use data are normalized to represent ETAW requirements under average and drought year water supply conditions. Land use data are also normalized. The Department collects land use data through periodic surveys; however, the entire State is not surveyed in any given year (such as 1995). To arrive at an estimate of historical statewide land use for a specific year, additional sources of data are consulted to interpolate between surveys. After a statewide historical land use base is constructed, it is evaluated to determine if it was influenced by abnormal weather or crop market conditions and is normalized to remove such influences.

Normalizing allows Bulletin 160-98 to define an existing level of development (i.e., the 1995 base year) that is compatible with a forecasted level of development (i.e., the 2020 forecast year). Future year shortage calculations implicitly rely on a comparison between future water use and existing water supply, as water supplies do not change significantly (without implementation of new facilities and programs) over the planning horizon. Therefore, the normalizing procedure is necessary to provide an appropriate future year shortage calculation. Normalizing also permits more than one water supply condition to be evaluated for a given level of development. If historical data were used to define the base year, only one specific hydrologic condition would be represented. (Historical data for 1995 would represent a wet year.) But through normalizing, a base level of development can be evaluated under a range of hydrologic conditions.

The 1990-91 drought year scenario has a recurrence interval of about 20 years, or a 5 percent probability of occurring in any given year. This is typical of the drought level used by many local agencies for routine water supply planning. For extreme events such as the 1976-77 drought, many agencies would implement shortage contingency measures such as mandatory rationing. Another important consideration in selecting water years 1990-91 was that, because of their recent occurrence, local agency water demand and supply data were readily available.

The statewide occurrence of dry conditions during the 1990-91 water years was another key consideration in selecting them as a representative drought. Because of the size of California, droughts may or may not occur simultaneously throughout the entire state.

Sources of Water Supply

Table ES3-1 shows California's estimated water supply, for average and drought years under 1995 and 2020 levels of development, with existing facilities and proand grams. Facility operations in the Delta are assumed to be in accordance with Order WR 95-6. The State's 1995-level average year water supply is about 77.9 maf, including about 31.4 maf of dedicated flows for environmental uses. As previously discussed, this supply is based on an applied water methodology and therefore includes considerable amounts of reapplication within hydrologic regions.

Even with a reduction in Colorado River supplies to California's 4.4 maf basic apportionment, annual average statewide supply is projected to increase about 0.2 maf by 2020 without implementation of new water supply options. While the expected increase in average year water supplies is due mainly to higher CVP and SWP deliveries (in response to higher 2020-level demands), new water production will also result from groundwater and from recycling facilities currently under construction.

The State's 1995-level drought year water supply is about 59.6 maf, of which about 16.6 maf is dedicated for environmental uses. Annual drought year supply is expected to increase slightly by 2020 without implementation of new water supply options. The expected increase would come from higher CVP

TABLE ES3-1

California Water Supplies with Existing Facilities and Programs[a] (taf)

Supply	*1995*		*2020*	
	Average	*Drought*	*Average*	*Drought*
Surface				
CVP	7,004	4,821	7,347	4,889
SWP	3,126	2,060	3,439	2,394
Other Federal Projects	910	694	912	683
Colorado River	5,176	5,227	4,400	4,400
Local Projects	11,054	8,484	11,073	8,739
Required Environmental Flow	31,372	16,643	31,372	16,643
Reapplied	6,441	5,596	6,449	5,575
Groundwater[b]	12,493	15,784	12,678	16,010
Recycled and Desalted	324	333	415	416
Total (rounded)	**77,900**	**59,640**	**78,080**	**59,750**

[a] Bulletin 160-98 presents water supply data as applied water, rather than net water. This distinction is explained in a previous section. Past editions of Bulletin 160 presented water supply data in terms of net supplies.

[b] Excludes groundwater overdraft

and SWP deliveries and new production from surface water, groundwater, and recycling facilities currently under construction.

Surface Water Supplies

Surface water includes developed supplies from the CVP, SWP, Colorado River, other federal projects, and local projects. Figure ES3-2 shows the location of the State's major water projects. Surface water also includes the supplies for required environmental flows. Required environmental flows are comprised of undeveloped supplies designated for wild and scenic rivers, supplies used for instream flow requirements, and supplies used for Bay-Delta water quality and outflow requirements. Finally, surface water includes supplies available for reapplication downstream. Urban wastewater discharges and agricultural return flows, if beneficially used downstream, are examples of reapplied surface water.

Groundwater Supplies

In an average year, about 30 percent of California's urban and agricultural applied water is provided by groundwater extraction. In drought years when surface supplies are reduced, groundwater supports an even larger percentage of use. The amount of water stored in California's aquifers is far greater than that stored in the State's surface water reservoirs, although only a portion of California's groundwater resources can be economically and practically extracted for use.

Bulletin 160-98 excludes long-term basin extractions in excess of long-term basin inflows in its definition of groundwater supply. This long-term average annual difference between extractions and recharge, defined in the Bulletin as overdraft, is not a sustainable source of water and is thus excluded from the base year and forecast year groundwater supply estimates. (In response to public comments on the Bulletin 160-93, Bulletin 160-98 is the first water plan update to exclude overdraft from the base year groundwater supply estimate.)

In wet years, recharge into developed groundwater basins tends to exceed extractions. Conversely, in dry years, groundwater basin recharge tends to be less than groundwater basin extraction. By definition, overdraft is not a measure of these annual fluctuations in groundwater storage volume. Instead, overdraft is a measure of the long-term trend associated with these annual fluctuations. The period of record used to evaluate overdraft must be long enough to produce data that, when averaged, approximate the long-term average hydrologic conditions for the basin. Table ES3-2 shows the Department's estimates of 1995 and 2020-level groundwater overdraft by hydrologic region. Within some regions, overdraft occurs in some well-defined subareas, while additional groundwater development potential may exist in other subareas.

For the 1995 base year, Bulletin 160-98 estimates a statewide increase in groundwater overdraft (160 taf) above the 1990 base year reported in Bulletin 160-93. Most of the statewide increase in overdraft occurred in the San Joaquin and Tulare Lake Regions, two regions

FIGURE ES3-2
California's Major Water Projects

TABLE ES3-2

1995 and 2020 Level Overdraft by Hydrologic Region (taf)

Region	1995		2020	
	Average	*Drought*	*Average*	*Drought*
North Coast	0	0	0	0
San Francisco Bay	0	0	0	0
Central Coast	214	214	102	102
South Coast	0	0	0	0
Sacramento River	33	33	85	85
San Joaquin River	239	239	63	63
Tulare Lake	820	820	670	670
North Lahontan	0	0	0	0
South Lahontan	89	89	89	89
Colorado River	69	69	61	61
Total (rounded)	**1,460**	**1,460**	**1,070**	**1,070**

where surface water supplies have been reduced in recent years by Delta export restrictions, CVPIA implementation, and ESA requirements. CVP contractors in these regions who rely on Delta exports for their surface water supply have experienced supply deficiencies of up to 50 percent subsequent to implementation of export limitations and CVPIA requirements. Many of these contractors have turned to groundwater pumping for additional water supplies. This long-term increase in groundwater extractions exacerbated a short-term decline in water levels as a result of the 1987-92 drought.

As shown in Table ES3-2, groundwater overdraft is expected to decline from 1.5 maf/yr to 1.1 maf/yr statewide by 2020. Overdraft in the Central Coast Region is expected to decline as demand shifts from groundwater to imported SWP supplies, provided through the recently completed Coastal Branch of the California Aqueduct. The reduction in irrigated acreage in drainage problem areas on the west side of the San Joaquin Valley, as described in the 1990 report of the San Joaquin Valley Interagency Drainage Program, is expected to reduce groundwater demands in the San Joaquin River and Tulare Lake regions by 2020. Some increases in groundwater overdraft are expected in Sacramento, Placer, and El Dorado Counties of the Sacramento River Region.

Water Marketing

In recent years, water marketing has received increasing attention as a tool for addressing statewide imbalances between water supply and water use. Experiences with water markets during and since the 1987-92 drought bolstered interest in using marketing as a local and statewide water supply augmentation option. While water marketing does allow water agencies to purchase additional water supply reliability during both average and drought years, water marketing does not create new water. Therefore, water markets alone cannot meet California's long-term water supply needs.

In this update of the *California Water Plan*, water marketing may include:

- A permanent sale of a water right by the water right holder.
- A lease from the water right holder (who retains the water right), allowing the lessee to use the water under specified conditions over a specified period of time.
- A sale or lease of a contractual right to water supply. Under this arrangement, the ability of the holder to transfer a contractual water right is usually contingent upon receiving approval from the supplier. An example of this type of arrangement is a sale or lease by a water agency that receives its supply from the CVP, SWP, or other water wholesaler.

Water marketing is not an actual statewide source of water, but rather is a means to reallocate existing supplies. Therefore, marketing is not explicitly itemized as a source of water supply from existing facilities and programs in the Bulletin 160 water budgets. (Water marketing agreements in place by 1995 are considered to be existing programs and are implicitly part of the water budgets.) Water marketing is identified as a potential water supply augmentation option in the Bulletin 160 water budgets. Potential water marketing options have several characteristics that must

TABLE ES3-3

Recently Completed Long-Term Water Marketing Agreements

Participants	*Region(s)*
Westside Water District, Colusa County Water District	Sacramento River
Semitropic Water Storage District, Santa Clara Valley Water District	Tulare Lake, San Francisco Bay
Semitropic Water Storage District, Alameda County Water District	Tulare Lake, San Francisco Bay
Semitropic Water Storage District, Zone 7 Water Agency	Tulare Lake, San Francisco Bay
Semitropic Water Storage District, Metropolitan Water District of Southern California	Tulare Lake, South Coast
Kern County Water Agency, Mojave Water Agency	Tulare Lake, South Lahontan
Arvin-Edison Water Storage District, Metropolitan Water District of Southern California	Tulare Lake, South Coast
Mojave Water Agency, Solano County Water Agency	South Lahontan, San Francisco Bay
Imperial Irrigation District, Metropolitan Water District of Southern California	Colorado River, South Coast

be captured in the water budgets incorporating supplies from future management options. For example, through changes in place of use, water marketing options can reallocate supplies from one hydrologic region to another. And through changes in type of use, water marketing options can reallocate supplies from one water use sector to another. Finally, for a given place and type of use, water marketing options can reallocate supplies among average years and drought years.

While several long-term agreements have been completed in recent years (see Table ES3-3), short-term agreements have made up the majority of water marketing. Short-term agreements, with terms less than one year, can be an effective means of alleviating the most severe drought year impacts. Short-term agreements can be executed on the spot market; however, water purveyors are increasingly interested in negotiating longer-term agreements for drought year transfers. In such future agreements, specific water supply conditions may be the triggers to determine whether water would be transferred in a specific year.

Two examples of programs for acquiring water through short-term agreements are the Drought Water Bank and the CVPIA interim water acquisition program. Beyond these programs, data on short-term water marketing arrangements are difficult to locate and verify. Agreements executed for less than one year do not need SWRCB approval (unless there is a change in place of use or point of diversion) and thus are not tracked by outside entities. Data are also difficult to evaluate, as it is often difficult to distinguish between exchanges and marketing arrangements.

Water Recycling and Desalting Supplies

Water recycling is the intentional treatment and management of wastewater to produce water suitable for reuse. Several factors affect the amount of wastewater treatment plant effluent that local agencies are able to recycle, including the size of the available market and the seasonality of demands. Local agencies must plan their facilities based on the amount of treatment plant effluent available and the range of expected service area demands. In areas where irrigation uses constitute the majority of recycled water demands, winter and summer demands may vary greatly. (Where recycled water is used for groundwater recharge, seasonal demands are more constant throughout the year.) Also, since water recycling projects are often planned to supply certain types of customers, the proximity of these customers to each other and to available pipeline distribution systems affects the economic viability of potential recycling projects.

Technology available today allows many municipal wastewater treatment systems to produce water supplies at competitive costs. More stringent treatment requirements for disposal of municipal and industrial wastewater have reduced the incremental cost for higher levels of treatment required for recycled water. The degree of additional treatment depends on the intended use. Recycled water is used for agricultural and landscape irrigation, groundwater recharge, and industrial and environmental uses. Some uses are required to meet more stringent standards for public health protection. An example is the City of San Diego's planned 18 mgd wastewater repurification facility. This water project would produce about 16 taf/yr of repurified water to augment local municipal supplies. If implemented, the project would be California's first planned indirect potable reuse project that discharges repurified water directly into a surface reservoir.

The use of recycled water can lessen the demand for new water supply. However, not all water recycling produces new water supply. Bulletin 160 counts water that would otherwise be lost to the State's hydrologic system (i.e., water discharged directly to the ocean or to another salt sink) as recycled water supply. If water recycling creates a new demand which would not otherwise exist, or if it treats water that would have otherwise been reapplied by downstream entities or recharged to usable groundwater, it is not considered new water supply. Water recycling provides multiple benefits such as reduced wastewater discharge and improved water quality.

The Department, in coordination with the WateReuse Association of California, conducted a 1995 survey to update the Association's 1993 survey of local agencies' current and planned water recycling. By 2020, total water recycling is expected to increase from 485 taf/yr to 577 taf/yr, due to greater production at existing treatment plants and new production at plants currently under construction. This base production is expected to increase new recycled supplies from 323 taf/yr to 407 taf/yr. All new recycled water is expected to be produced in the San Francisco Bay, Central Coast, and South Coast Regions. Table ES3-4 shows future potential options for water recycling.

TABLE ES3-4

2020 Level Total Water Recycling and New Water Supply (taf)

Projects	*Total Water Recycling*	*New Water Supply*
Base	577	407
Options	835	655
Total	1,412	1,062

By 2020, water recycling options could bring total water recycling potential to over 1.4 maf/yr, potentially generating as much as 1.1 maf/yr of new supply, if water agencies implemented all projects identified in the survey.

The capacity of California's existing desalting plants totals about 66 taf annually; feedwater sources are brackish groundwater, wastewater, and seawater. Total seawater desalting capacity is currently about 8 taf/yr statewide. Most existing plants are small (less than 1 taf/yr) and have been constructed in coastal communities with limited water supplies. The Santa Barbara desalting plant, with capacity of 7.5 taf/yr, is currently the only large seawater desalting plant. The plant was constructed during the 1987-92 drought and is now on long-term standby. In the 1995-level water budget, 8 taf of seawater desalting is included as a drought year supply. In the 2020-level water budget, 8 taf of seawater desalting is included as average and drought year supplies.

Water Supply Summary by Hydrologic Region

Table ES3-5 summarizes average year water supplies by hydrologic region assuming 1995 and 2020 levels of development and existing facilities and programs. Similarly, Table ES3-6 summarizes drought year water supplies by hydrologic region for existing and future levels of development. Regional water supplies, along with water demands presented in the following chapter, provide the basis for the statewide water budget developed in Chapter ES5 and regional water budgets developed in Appendices ES5A and ES5B.

Water Quality

A critical factor in determining the usability and reliability of any particular water source is water quality. The quality of a water source will significantly affect the beneficial uses of that water. Water has many potential uses, and the water quality requirements for each use vary. Sometimes, different water uses may have conflicting water quality requirements. For example, water temperatures ideal for irrigation of some crops may not be suitable for fish spawning.

The establishment and enforcement of water quality standards for water bodies in California fall under the authority of SWRCB and the nine regional water quality control boards. The RWQCBs protect water quality through adoption of region-specific water quality control plans, commonly known as basin plans. In general, water quality control plans designate beneficial uses of water and establish water quality objectives designed to protect them. The designated beneficial uses of water may vary between individual water bodies.

Water quality objectives are the limits or levels of water quality constituents or characteristics which are established to protect beneficial uses. Because a particular water body may have several beneficial uses, the water quality objectives established must be protective of all designated uses. When setting water quality objectives, several sources of existing water quality limits are used, depending on the uses designated in a water quality control plan. When more than one water quality limit exists for a water quality constituent or characteristic (e.g., human health limit vs. aquatic life limit), the more restrictive limit is used as

TABLE ES3-5

California Average Year Water Supplies by Hydrologic Region (with existing facilities and programs, in taf)

Region	1995 Surface	1995 Groundwater[a]	1995 Recycled & Desalted	1995 Total (rounded)	2020 Surface	2020 Groundwater[a]	2020 Recycled & Desalted	2020 Total (rounded)
North Coast	20,331	263	13	20,610	20,371	288	13	20,670
San Francisco Bay	7,011	68	35	7,110	7,067	72	37	7,180
Central Coast	318	1,045	18	1,380	368	1,041	42	1,450
South Coast	3,839	1,177	207	5,220	3,625	1,243	273	5,140
Sacramento River	11,881	2,672	0	14,550	12,196	2,636	0	14,830
San Joaquin River	8,562	2,195	0	10,760	8,458	2,295	0	10,750
Tulare Lake	7,888	4,340	0	12,230	7,791	4,386	0	12,180
North Lahontan	777	157	8	940	759	183	8	950
South Lahontan	322	239	27	590	437	248	27	710
Colorado River	4,154	337	15	4,510	3,920	285	15	4,220
Total (rounded)	**65,090**	**12,490**	**320**	**77,900**	**64,990**	**12,680**	**410**	**78,080**

[a] Excludes groundwater overdraft.

TABLE ES3-6

California Drought Year Water Supplies by Hydrologic Region (with existing facilities and programs, in taf)

Region	1995 Surface	1995 Groundwater[a]	1995 Recycled & Desalted	1995 Total (rounded)	2020 Surface	2020 Groundwater[a]	2020 Recycled & Desalted	2020 Total (rounded)
North Coast	10,183	294	14	10,490	10,212	321	14	10,550
San Francisco Bay	5,285	92	35	5,410	5,417	89	37	5,540
Central Coast	160	1,142	26	1,330	180	1,159	42	1,380
South Coast	3,196	1,371	207	4,780	3,130	1,462	273	4,870
Sacramento River	10,022	3,218	0	13,240	10,012	3,281	0	13,290
San Joaquin River	6,043	2,900	0	8,940	5,986	2,912	0	8,900
Tulare Lake	3,693	5,970	0	9,660	3,593	5,999	0	9,590
North Lahontan	557	187	8	750	557	208	8	770
South Lahontan	259	273	27	560	326	296	27	650
Colorado River	4,128	337	15	4,480	3,909	284	15	4,210
Total (rounded)	**43,530**	**15,780**	**330**	**59,640**	**43,320**	**16,010**	**420**	**59,750**

[a] Excludes groundwater overdraft.

the water quality objective.

Drinking water standards for a total of 81 individual drinking water constituents are in place under the mandates of the 1986 SDWA amendments. By the new SDWA standard setting process established in the 1996 amendments, EPA will select at least five new candidate constituents to be considered for regulation every five years. Selection of the new constituents for regulation must be geared toward contaminants posing the greatest health risks.

Occasionally, drinking water regulatory goals may conflict. For example, concern over pathogens such as *Cryptosporidium* spurred a proposed rule requiring more rigorous disinfection. At the same time, there was considerable regulatory concern over trihalomethanes and other disinfection by-products resulting from disinfecting drinking water with chlorine. However, if disinfection is made more rigorous, disinfection by-product formation is increased. Poor quality source waters with elevated concentrations of organic precursors and bromides further complicate the problem of reliably meeting standards for disinfection while meeting standards for disinfection by-products. The regulatory community will have to balance the benefits and risks associated with pursuing the goals of efficient disinfection and reduced disinfection by-products.

EPA promulgated its Information Collection Rule in 1996 to obtain the data on the tradeoff posed by simultaneous control of disinfection by-products and pathogens in drinking water. The ICR requires all large public water systems to collect and report data on the occurrence of disinfection by-products and pathogens (including bacteria, viruses, *Giardia*, and *Cryptosporidium*) in drinking water over an 18-month period. With this information, an assessment of health risks due to the presence of disinfection by-products and pathogens in drinking water can be made. EPA can then determine the need to revise current drinking water filtration and disinfection requirements, and the need for more stringent regulations for disinfectants and disinfection by-products.

There has been growing concern over the potential human health threat of pathogens in groundwater. This concern stems from pathogens such as *Giardia*, *Cryptosporidium*, bacteria, and viruses being found in water taken from wells. The concern about pathogens in groundwater has led to regulatory discussions on disinfection requirements for groundwater. It is currently estimated that the Groundwater Disinfection Rule will be proposed sometime in 1999 and will become effective in 2002. The data obtained through the ICR will provide the necessary information to assess the extent and severity of risk.

The SDWA requires states to implement wellhead protection programs designed to prevent the contamination of groundwater supplying public drinking water wells. Wellhead protection programs rely heavily on local efforts to be effective, because communities have the primary access to information on potential contamination sources and can adopt locally-based measures to manage these potential contamination sources.

CCWD's Los Vaqueros Dam under construction. The reservoir does not provide new water supply, but provides terminal storage for CCWD's existing supply and improves service area water quality.

4

Executive Summary

Urban, Agricultural, and Environmental Water Use

This chapter describes present and forecasted urban, agricultural, and environmental water use. The chapter is organized into three major sections, one for each category of water use.

Water use information is presented at the hydrologic region level of detail under normalized hydrologic conditions. Forecasted 2020-level urban and agricultural water use have not changed greatly since publication of Bulletin 160-93. Forecasted urban water use depends heavily on population forecasts. Although the Department of Finance has updated its California population projections since the last Bulletin, U.S. census data are an important foundation for the projections, and a new census will not be performed until 2000. The Department's forecasts of agricultural water use change relatively slowly in the short-term, because the corresponding changes in forecasted agricultural acreage are a small percentage of the State's total irrigated acreage. Changes in base year and forecasted environmental water use from the last Bulletin reflect implementation of SWRCB's Order WR 95-6 for the Bay-Delta.

Nursery products are California's third largest farm product in gross value. The nursery industry is affected by the availability of both agricultural and urban water supplies.

Urban Water Use

Forecasts of future urban water use for the Bulletin are based on population information and per capita water use estimates. Factors influencing per capita water use include expected demand reduction due to implemen-

-tation of water conservation programs. The Department has modeled effects of conservation measures and socioeconomic changes on per capita use in 20 major water service areas to estimate future changes in per capita use by hydrologic region. An urban water agency making estimates for its own service area would be able to incorporate more complexity in its forecasting, because the scope of its effort is narrow. For this reason, and because DOF population projections seldom exactly match population projections prepared by cities and counties, the Bulletin's water use forecasts are expected to be representative of, rather than identical to, those of local water agencies.

Population Growth

Data about California's population—its geographic distribution and projections of future populations and their distribution—come from several sources. The Department works with base year and projected year population information developed by DOF for each county in the State. The decadal census is a major benchmark for population projections. DOF works from census data to calculate the State's population in noncensus years, and to project future populations. Figure ES4-1 shows DOF's projected growth rates by county for year 2020. (State policy requires that all State agencies use DOF population projections for planning, funding, and policymaking activities.)

Population projections used in Bulletin 160-98 are based on DOF's *Interim County Population Projections (April 1997)*. Table ES4-1 shows the 1995 through 2020 population figures for Bulletin 160-98 by hydrologic region.

TABLE ES4-1
California Population by Hydrologic Region (in thousands)

Region	*1995*	*2020*
North Coast	606	835
San Francisco Bay	5,780	7,025
Central Coast	1,347	1,946
South Coast	17,299	24,327
Sacramento River	2,372	3,813
San Joaquin River	1,592	3,025
Tulare Lake	1,738	3,296
North Lahontan	84	125
South Lahontan	713	2,019
Colorado River	533	1,096
Total (rounded)	**32,060**	**47,510**

DOF periodically updates its population forecasts to respond to changing conditions. Its 2020 population forecast used for Bulletin 160-93 was 1.4 million higher than the 2020 forecast used in Bulletin 160-98. The latter forecast incorporated the effects of the recession of the early 1990s. Small fluctuations in the forecast do not obscure the overall trend—an increase in population on the order of 50 percent.

The Department apportioned county population data to Bulletin 160 study areas based on watershed or water district boundaries. Factors considered in distributing the data to Bulletin 160 study areas included population projections prepared by cities, counties, and local councils of governments, which typically incorporate expected future development from city and county general plans. The local agency projections indicate which areas within a county are expected to experience growth, and provide guidance in allocating DOF's projection for an entire county into smaller Bulletin 160 study areas.

Factors Affecting Urban Per Capita Water Use

Urban per capita water use includes residential, commercial, industrial, and institutional uses of water. Each of these categories can be examined at a greater level of detail. Residential water use, for example, includes interior and exterior (e.g., landscaping) water use. Forecasts of urban water use for an individual community may be separated into components and forecasted individually. It is not possible to use this level of detail for each community in the State in Bulletin 160-98. Bulletin 160-98 modeled components of urban use for representative urban water agencies in each of the State's ten hydrologic regions and extrapolated those results to the remainder of each hydrologic region.

Demand reduction achieved by implementing water conservation measures is important in forecasting per capita water use. Bulletin 160-98 incorporates demand reductions from implementation of urban best management practices contained in the 1991 *Memorandum of Understanding Regarding Urban Water Conservation in California*. Bulletin 160-98 assumes implementation of the urban MOU's BMPs by 2020, resulting in a demand reduction of about 1.5 maf over the year 2020 demand forecast without BMP implementation.

The relationship of water pricing to water consumption, and the role of pricing in achieving water conservation, has been a subject of discussion in recent years. Elected board members of public water

FIGURE ES4-1

Projected Growth Rates by County, 1995-2020

TABLE ES4-2

Effects of Conservation on Per Capita Water Use[a] by Hydrologic Region (gallons per capita per day)

Region	*1995*	*2020*	
		without conservation	*with conservation*
North Coast	249	236	215
San Francisco Bay	192	188	166
Central Coast	179	188	166
South Coast	208	219	191
Sacramento River	286	286	264
San Joaquin River	310	307	274
Tulare Lake	298	302	268
North Lahontan	411	390	356
South Lahontan	282	294	268
Colorado River	564	626	535
Statewide	**229**	**243**	**215**

[a] Includes residential, commercial, industrial, and landscape use supplied by public water systems and self-produced surface and groundwater. Does not include recreational use, energy production use, and losses from major conveyance facilities. These are normalized data.

agencies ultimately have the responsibility for balancing desires to achieve demand reduction through water pricing with desires to provide affordable water rates to consumers. Urban water rates in California vary widely and are affected by factors such as geographic location, source of supply, and type of water treatment provided. Water rates are set by local agencies to recover costs of providing water service, and are highly site-specific. According to several price elasticity studies for urban water use, residential water demand is usually inelastic, i.e., water users were relatively insensitive to changes in price for the price ranges evaluated. Water price currently plays a small role in relation to other factors affecting water use—public education, plumbing retrofit programs, etc.

High efficiency horizontal axis washing machines (front loading washers) are being used in commercial applications, but are just becoming available for home use. A check of large appliance dealers in 1998 showed that two brands of horizontal axis washers are commonly in stock, at prices ranging from $700 to $1,100. Comparable standard washers cost from $100 to $600 less. Some utilities are offering their customers rebates on the order of $100 to $150 for purchasing the horizontal axis machines.

Urban Water Use Forecasting

The Department forecasted change in per capita water use by 2020 in each hydrologic region to estimate 2020 urban applied water by hydrologic region. Variables included changes in population, income, economic activity, water price, and conservation measures (implementation of urban BMPs and changes to State and federal plumbing fixture standards). The general forecasting procedure was to determine 1995 base per capita water use, estimate the effects of conservation measures and socioeconomic change on future use for 20 major representative water service areas in California, and calculate 2020 base per capita water use by hydrologic region from the results of service area forecasts. (See Table ES4-2.)

Summary of Urban Water Use

Table ES4-3 summarizes Bulletin 160-98 urban applied water use by hydrologic region. Statewide urban use at the 1995 base level is 8.8 maf in average water years and 9.0 maf in drought years. (Drought year demands are slightly higher because less precipitation is available to meet exterior urban water uses, such as landscape watering.) Projected 2020 use increases to 12.0 maf in average years and 12.4 maf in drought years. Full implementation of urban BMPs is estimated to result in demand reduction of 1.5 maf in average year water use by 2020. Without implementation of urban BMPs, average year use would have increased to 13.5 maf.

As indicated in the Table ES4-3, the South Coast and San Francisco Bay Hydrologic Regions together amount to over half of the State's total urban water use. The table also illustrates that precipitation plays a small role in meeting urban outdoor water needs (landscape water needs) in arid regions such as the Tulare Lake, South Lahontan, and Colorado River Regions.

Agricultural Water Use

The Department's estimates of agricultural water use are derived by multiplying water use requirements for different crop types by their corresponding statewide irrigated acreage, and summing the results to obtain a total for irrigated crops in the State. This section begins by covering crop water use requirements. A description of the process for estimating future irrigated acreage, and factors affecting acreage forecasts, follows. Forecasted 2020 agricultural water demands are summarized at the end of the section.

Crop Water Use

The water requirement of a crop is directly related to the water lost through evapotranspiration. The amount of water that can be consumed through ET depends in the short term on local weather and in the long term on climatic conditions. Energy from solar radiation is the primary factor that determines the rate of crop ET. Also important are humidity, temperature, wind, stage of crop growth, and the size and aerodynamic roughness of the crop canopy. Irrigation frequency affects ET after planting and during early growth, because evaporation increases when the soil surface is wet and is exposed to sunlight. Growing season ET varies significantly among crop types, depending primarily on how long the crop actively grows.

Direct measurement of crop ET requires costly investments in time and in sophisticated equipment. There are more than 9 million acres of irrigated crop land in California, encompassing a wide range of climate, soils, and crops. Even where annual ET for two areas is similar, monthly totals may differ. For example, average annual ET for Central Coast interior valleys is similar to that in the Central Valley. Central Valley ET is lower than that in coastal valleys during the winter fog season, and higher during hot summer weather. Obtaining actual measurements for every combination of environmental variables would be prohibitively difficult and expensive. A more practical approach is to estimate ET using methods based on correlation of measured ET with observed evaporation, temperature, and other climatologic conditions. Such methods can

TABLE ES4-3

Applied Urban Water Use by Hydrologic Region (taf)

Region	*1995*		*2020*	
	Average	*Drought*	*Average*	*Drought*
North Coast	169	177	201	212
San Francisco Bay	1,255	1,358	1,317	1,428
Central Coast	286	294	379	391
South Coast	4,340	4,382	5,519	5,612
Sacramento River	766	830	1,139	1,236
San Joaquin River	574	583	954	970
Tulare Lake	690	690	1,099	1,099
North Lahontan	39	40	50	51
South Lahontan	238	238	619	619
Colorado River	418	418	740	740
Total (rounded)	**8,770**	**9,010**	**12,020**	**12,360**

be used to transfer the results of measured ET to other areas with similar climates.

The Department uses the ET/evaporation correlation method to estimate growing season ET. Concurrent with field measurement of ET rates, the Department developed a network of agroclimate stations to determine the relationship between measured ET rates and pan evaporation. Data from agroclimatic studies show that water evaporation from a standard water surface (the Department uses the U.S. Weather Bureau Class A evaporation pan) closely correlates to crop evapotranspiration. The ET/evaporation method estimates crop water use to within ± 10 percent of measured seasonal ET.

Crop coefficients are applied to pan evaporation data to estimate evapotranspiration rates for specific crops. (Crop coefficients vary by crop, stage of crop growth, planting and harvest dates, and growing season duration.) The resulting data, combined with information on effective rainfall and water use efficiency, form the basis for calculating ETAW and applied water use. Crop applied water use includes the irrigation water required to meet crop ETAW and cultural water requirements.

The amount of water applied to a given field for crop production is influenced by considerations such as crop water requirements, soil characteristics, the ability of an irrigation system to distribute water uniformly on a given field, and irrigation management practices. In addition to ET, other crop water requirements can include water needed to leach soluble salts below the crop root zone, water that must be applied for frost protection or cooling, and water for seed germination. The amount required for these uses depends upon the crop, irrigation water quality, and weather conditions.

Part of a crop's water requirements can be met by rainfall. The amount of rainfall beneficially used for crop production is called effective rainfall. Effective rainfall is stored in the soil and is available to satisfy crop evapotranspiration or to offset water needed for special cultural practices such as leaching of salts. Irrigation provides the remainder of the crop water requirement. Irrigation efficiency influences the amount of applied water needed, since a portion of each irrigation goes to system leaks and deep percolation of irrigation water below the crop root zone.

The Bulletin's 1995 base applied agricultural water use values were computed from normalized data to account for variation in annual weather patterns and water supply. Normalizing entails applying crop coefficients to long-term average evaporative demand data. Actual applied crop water use during 1995 was less than the Bulletin 160-98 base in many areas due to wet hydrologic conditions that increased effective rainfall, thus decreasing crop ETAW. Likewise, applied water use during a dry year (assuming no constraints on water supplies) would likely exceed the base due to less than average effective rainfall with an attendant increase in crop ETAW.

Bulletin 160-98 quantifies agricultural water conservation based on assumed statewide implementation of the 1996 agricultural MOU. This conservation is expected to reduce agricultural applied water demands by about 800 taf annually by 2020.

Quantifying Base Year Irrigated Acreage

Forecasts of agricultural acreage start with land use data that characterize existing crop acreage. The Department has performed land use surveys since the 1950s to quantify acreage of irrigated land and corresponding crop types, and currently maps irrigated acreage in six to seven counties per year. The base data for land use surveys are obtained from aerial photography or satellite imagery, which is superimposed on a cartographic base. Site visits are used to identify or verify crop types growing in the fields. From this information, maps showing locations and acreage of crop types are developed.

The Department's land use surveys focus on quantifying irrigated agricultural acreage. Although fields of dry-farmed crops are mapped in the land use surveys, their acreage is not tabulated for calculating water use. In certain areas of the State, climate and market conditions are favorable for producing multiple crops per year on the same field (for example, winter vegetables followed by a summer field crop). In these cases, annual irrigated acreage is counted as the sum of the acreage of the individual crop types. In the years between county land use surveys, the Department estimates crop types and acreage using data collected from county agricultural commissioners, local water agencies, University of California Cooperative Extension Programs, and the California Department of Food and Agriculture.

The starting point for determining Bulletin 160-98 1995 base acreage was normalized 1990 irrigated acreage from Bulletin 160-93. Changes in crop acreage between 1990 and 1995 were evaluated to determine if they were due to short-term causes (e.g., drought or abnormal spring rainfall), or if there was an actual change in cropping patterns. Base year acreage was normalized to represent the acreage that would most likely occur in the absence of weather and market related abnormalities.

Crop acreage by region for the normalized 1995 base is presented in Table ES4-4. The 1995 base irrigated land acreage is about 9.1 million acres, which, when multiple cropped areas are tabulated, becomes a base irrigated cropped acreage of about 9.5 million acres.

Forecasting Future Irrigated Acreage

The Department's 2020 irrigated acreage forecast was derived from staff research, a crop market outlook study, and results from the Central Valley Production Model. As with any forecast of future conditions, there are uncertainties associated with each of these approaches. The Department's integration of the results from three independent approaches is intended to represent a best estimate of future acreage, absent major changes from present conditions. It is important to emphasize that many factors affecting future cropped acreage are based on national (federal Farm Bill programs) or international (world export markets) circumstances. California agricultural products compete with products from other regions in the global economy, and are affected by trade policies and market conditions that reach far beyond the State's boundaries.

The Federal Agriculture Improvement and Reform Act of 1996, for example, affects agricultural markets nationwide, by changing federal price supports for specified agricultural commodities. Under the terms of that act, federal payments to growers will be reduced by 2002, and prior farm bill provisions that required growers to reduce planted acreage of regulated commodities are no longer in force. (Commodities with significant federal price support include wheat, feed grains, rice, cotton, dairy products, sugar, and peanuts.) The overall impact of the act to California, however, may be less than its impact to states whose agriculture is less diversified and who are less active in export markets. In 1994, for example, federal farm bill production payments to California growers represented about one percent of California's agricultural revenue. The potential impacts of FAIRA to California's agricultural market are considered in Bulletin 160-98 by the crop market outlook study.

Intrastate factors considered in making acreage forecasts included urban encroachment onto agricultural land and land retirement due to drainage problems. Urbanization on lands presently used for irrigated agriculture is a significant consideration in the South Coast Region and in the San Joaquin Valley, based on projected patterns of population growth. DOF 2020 population forecasts, along with information gathered from local agency land use plans, were used to identify irrigated lands most likely to be affected by urbanization. Local water agencies and county farm advisors were interviewed to assess their perspective on land use changes affecting agricultural acreage. For example, urbanization may eliminate irrigated acreage in one area, but shift agricultural development onto lands presently used as non-irrigated pasture. Soil types and landforms are important constraints in agricultural land development. If urbanization occurs on prime Central Valley farmland, some agricultural production may be able to shift to poorer quality soils on hilly lands adjoining the valley floor. A consequent shift in crop types and irrigation practices would likely result—for example, from furrow-irrigated row crops to vineyards on drip irrigation.

The Department's crop market outlook, a form of Delphi analysis, was developed using information and expert opinions gathered from interviews with more than 130 University of California farm advisors, agricultural bankers, commodity marketing specialists,

Factors that influence the conversion of irrigated lands to urban use include the lands' proximity to existing urban areas and transportation corridors, and local agency land use planning and zoning policies.

TABLE ES4-4

California Crop and Irrigated Acreage by Hydrologic Region, 1995 Level
(thousands of acres)

Irrigated Crop	*NC*	*SF*	*CC*	*SC*	*SR*	*SJ*	*TL*	*NL*	*SL*	*CR*	*Total*
Grain	72	2	26	11	270	180	260	7	2	70	900
Rice	0	0	0	0	494	22	0	1	0	0	517
Cotton	0	0	0	0	9	185	1,026	0	0	24	1,244
Sugar beets	6	0	3	0	54	47	30	0	0	38	178
Corn	1	1	3	4	92	212	116	0	0	9	438
Other field	3	1	16	4	155	120	97	0	1	70	467
Alfalfa	53	0	21	10	149	231	296	44	34	256	1,094
Pasture	122	5	18	20	352	199	49	107	18	43	933
Tomatoes	0	0	10	7	138	82	111	0	0	9	357
Other truck	23	11	382	87	56	130	194	2	3	172	1,060
Almond/pistachios	0	0	0	0	106	251	177	0	0	0	534
Other deciduous	7	6	18	3	219	154	191	0	3	1	602
Subtropical	0	0	19	161	28	8	202	0	0	37	455
Grapes	36	39	56	6	17	184	378	0	0	20	736
Total Crop Area	**323**	**65**	**572**	**313**	**2,139**	**2,005**	**3,127**	**161**	**61**	**749**	**9,515**
Multiple Crop	0	0	142	30	52	56	63	0	0	104	447
Irrigated Land Area	323	65	430	283	2,087	1,949	3,064	161	61	645	9,068

managers of cooperatives, and others. Three basic factors guided the CMO: current and future demand for food and fiber by the world's consumers; the share California could produce to meet this worldwide demand; and technical factors, such as crop yields, pasture carrying capacities, and livestock feed conversion ratios that affect demand for agricultural products. (Milk and dairy products are California's largest agricultural product, in terms of gross value. The demand for these products is reflected in the markets for alfalfa, grains, and other fodder used by dairies.) The CMO forecasts a statewide crop mix and estimates corresponding irrigated acreage. The major findings of the CMO for year 2020 were that grain and field crop acreage would decrease, while acreage of truck crops and permanent crops would increase.

The Central Valley Production Model is a mathematical programming model that simulates farming decisions by growers. Inputs include detailed information about production practices and costs as well as water availability and cost by source. The model also uses information on the relationship between production levels of individual crops and crop market prices. The model's geographic coverage is limited to the Central Valley, which represents about 80 percent of the State's irrigated agricultural acreage. The CVPM results also indicated future crop shifting, from grains and field crops to vegetables, trees, and vines. The CVPM forecast showed a small reduction in crop acreage from 1995 to 2020.

One factor not included in Bulletin 160-98 irrigated acreage forecasts is the potential large-scale conversion of agricultural land to wildlife habitat for reasons other than westside San Joaquin Valley problems. The CALFED program represents the largest pending example of potential conversion of irrigated agricultural lands to habitat, as described in CALFED's March 1998 first draft programmatic EIR/EIS and supporting documents. CALFED's potential land conversion amounts have not been included in the Bulletin 160-98 irrigated acreage forecast because they are preliminary at this time (a site-specific environmental document with an implementation schedule for land conversion has not yet been prepared), and because CALFED's preliminary numbers are so large relative to the Bulletin's market-based forecast of irrigated acreage that they would negate the results of the forecast. Overall, CALFED program activities as presently planned could convert up to 290,000 irrigated acres to habitat and other uses, an amount almost as great as the 325,000-acre reduction in irrigated acreage forecast in the Bulletin. Water use implications of large-scale land conversions are not included in the Bulletin 160-98 forecast. Impacts of such land conversions are expected to be addressed in the next water plan update, when CALFED's program may be better defined.

There is a perception that only drip irrigation is an efficient agricultural water use technology. High efficiencies are possible with a variety of irrigation techniques. Considerations such as soil type, field configuration, and crop type influence the choice of irrigation technique.

The difficulty in estimating impacts from large-scale land conversion programs stems from the domino effect that changes in acreage in one location have on acreage and crop types in other areas, and how crop markets determine which crop shifts are feasible. For example, CALFED's preliminary reports suggest that up to 190,000 irrigated acres in the Delta could be converted to other land uses. This amount represents about 40 percent of Delta irrigated acreage, whose principal crops are corn, alfalfa, tomatoes, grain, orchard crops, and truck crops (e.g., asparagus). Some land conversion in the Delta might result in production on new agricultural lands—most likely, rolling hills on the edge of the valley floor which are only suitable for limited crop types (orchards and vineyards). Some of the land conversion might result in increased demand in other areas for the affected crops, such as increased demand for asparagus from the Imperial and Salinas Valleys.

Table ES4-5 shows the 2020 irrigated acreage fore-

TABLE ES4-5

California Crop and Irrigated Acreage by Hydrologic Region, 2020 Level
(thousands of acres)

Irrigated Crop	*NC*	*SF*	*CC*	*SC*	*SR*	*SJ*	*TL*	*NL*	*SL*	*CR*	*Total*
Grain	66	1	21	5	249	152	201	8	0	97	800
Rice	0	0	0	0	484	15	0	1	0	0	500
Cotton	0	0	0	0	15	171	888	0	0	46	1,120
Sugar beets	6	0	2	0	52	18	13	0	0	29	120
Corn	2	0	3	2	90	188	101	1	0	3	390
Other field	3	1	14	1	154	139	110	0	0	33	455
Alfalfa	62	0	20	6	147	181	238	50	24	217	945
Pasture	123	5	16	6	316	165	26	103	18	32	810
Tomatoes	0	0	8	4	141	93	130	0	0	14	390
Other truck	28	11	373	43	79	197	300	2	1	231	1,265
Almond/pistachios	0	0	0	0	127	270	198	0	0	0	595
Other deciduous	7	6	20	3	234	153	199	0	2	1	625
Subtropical	0	0	18	117	33	10	215	0	0	32	425
Grapes	38	41	75	3	29	183	366	0	0	15	750
Total Crop Area	**335**	**65**	**570**	**190**	**2,150**	**1,935**	**2,985**	**165**	**45**	**750**	**9,190**
Multiple Crop	0	0	150	10	70	80	100	0	0	145	555
Irrigated Land Area	335	65	420	180	2,080	1,855	2,885	165	45	605	8,635

TABLE ES4-6

Applied Agricultural Water Use by Hydrologic Region (taf)

	1995		*2020*	
Region	*Average*	*Drought*	*Average*	*Drought*
North Coast	894	973	927	1,011
San Francisco Bay	98	108	98	108
Central Coast	1,192	1,279	1,127	1,223
South Coast	784	820	462	484
Sacramento River	8,065	9,054	7,939	8,822
San Joaquin River	7,027	7,244	6,450	6,719
Tulare Lake	10,736	10,026	10,123	9,532
North Lahontan	530	584	536	594
South Lahontan	332	332	257	257
Colorado River	4,118	4,118	3,583	3,583
Total (rounded)	**33,780**	**34,540**	**31,500**	**32,330**

cast. The total irrigated crop acreage is forecasted to decline by 325,000 acres from 1995 to 2020, primarily in the San Joaquin Valley and South Coast areas. Reductions in crop acreage are due to urban encroachment, drainage problems in the westside San Joaquin Valley, and a more competitive economic market for California agricultural products. Grain and field crops are forecasted to decline by about 631,000 acres. Truck crops and permanent crops are forecasted to increase by about 238,000 and 68,000 acres, respectively. Acreage with multiple cropping is forecasted to increase by 108,000 acres, reflecting the expected increased production of truck crops. These statewide findings are used in developing the base year and forecasted agricultural water demands.

Summary of Agricultural Water Use

Crop water use information and irrigated acreage data are combined to generate the 2020 agricultural water use by hydrologic region shown in Table ES4-6. As previously noted, the 2020 forecasted values take into account EWMP implementation, which results in a 2020 applied water reduction of about 800 taf.

Environmental Water Use

Bulletin 160-98 defines environmental water as the sum of:

- Dedicated flows in State and federal wild and scenic rivers
- Instream flow requirements established by water right permits, DFG agreements, court actions, or other administrative documents
- Bay-Delta outflows required by SWRCB
- Applied water demands of managed freshwater wildlife areas

This definition recognizes that certain quantities of water have been set aside or otherwise managed for environmental purposes, and that these quantities cannot be put to use for other purposes in the locations where the water has been reserved or otherwise managed. This definition also recognizes that these uses of environmental water can be quantified. Unlike urban and agricultural water use, much of this environmental water use is brought about by legislative or regulatory processes. Certainly the environment uses more water than is encompassed in this definition—the rainfall that sustains the forests of the Sierra Nevada and the North Coast, the winter runoff that supports flora and fauna in numerous small streams, the shallow groundwater that supports riparian vegetation in some ephemeral streams—but the Bulletin's definition captures uses of water that are managed (in one fashion or another) and quantifiable. As described earlier, average annual statewide precipitation over California's land surface amounts to about 200 maf. About 65 percent of this precipitation is consumed through evaporation and transpiration by the State's forests, grasslands, and other vegetation. The remaining 35 percent comprises the State's average annual runoff of about 71 maf. The environmental water demands discussed in this section are demands that would be met through a designated portion of that average annual runoff. As with urban and agricultural water use, environmental water use is shown on an applied water basis.

TABLE ES4-7

Wild and Scenic River Flows by Hydrologic Region (taf)

Region	1995		2020	
	Average	Drought	Average	Drought
North Coast	17,800	7,900	17,800	7,900
San Francisco Bay	0	0	0	0
Central Coast	98	28	98	28
South Coast	69	51	69	51
Sacramento River	1,733	736	1,733	736
San Joaquin River	1,974	939	1,974	939
Tulare Lake	1,614	751	1,614	751
North Lahontan	271	154	271	154
South Lahontan	0	0	0	0
Colorado River	0	0	0	0
Total (rounded)	**23,560**	**10,560**	**23,560**	**10,560**

Wild and Scenic River Flows

Flows in wild and scenic rivers constitute the largest environmental water use in the State. Figure ES4-2 is a map of California's State and federal wild and scenic rivers.

The 1968 National Wild and Scenic Rivers Act, codified to preserve the free-flowing characteristics of rivers having outstanding natural resources values, prohibited federal agencies from constructing, authorizing, or funding the construction of water resources projects having a direct or adverse effect on the values for which the river was designated. (This restriction also applies to rivers designated for potential addition to the national wild and scenic rivers system.) There are two methods for having a river segment added to the federal system—congressional legislation, or a state's petition to the Secretary of the Interior for federal designation of a river already protected under state statutes. No new federal designations have been made since publication of Bulletin 160-93.

A number of river systems within lands managed by federal agencies are being studied as candidates. For example, USFS draft environmental documentation in 1994 and 1996 recommended designation of five streams (129 river miles) in Tahoe National Forest and 160 river miles in Stanislaus National Forest. These waterways drain to the Central Valley where their flows are used for other purposes, and wild and scenic designation would not affect the existing downstream uses.

The California Wild and Scenic Rivers Act of 1972 prohibited construction of any dam, reservoir, diversion, or other water impoundment on a designated river. As shown on Figure ES4-2, some rivers are included in both federal and State systems. No new State designations have been made since Bulletin 160-93, although the Mill and Deer Creeks Protection Act of 1995 (Section 5093.70 of the Public Resources Code) gave portions of these streams special status similar to wild and scenic designation by restricting construction of dams, reservoirs, diversions, or other water impoundments.

Table ES4-7 shows the wild and scenic river flows used in Bulletin 160-98 water budgets by hydrologic region. The flows shown are based on the rivers' unimpaired flow. (The unimpaired flow in a river is the flow measured or calculated at some specific location that would be unaffected by stream diversions, storage, imports or exports, and return flows.) For the average year condition, the long-term unimpaired flow from the Department's Bulletin 1 was used. The estimated average unimpaired flow for the 1990-91 water years was used for the drought condition.

Instream Flows

Instream flow is the water maintained in a stream or river for instream beneficial uses such as fisheries, wildlife, aesthetics, recreation, and navigation. Instream flow is a major factor influencing the productivity and diversity of California's rivers and streams.

Instream flows may be established in a variety of ways—by agreements executed between DFG and a water agency, by terms and conditions in a water right permit from SWRCB, by terms and conditions in a FERC hydropower license, by a court order, or by an agreement among interested parties. Required flows on most rivers vary by month and year type, with wet year requirements generally being higher than dry year requirements. Converting from net water use analyses performed for prior editions of Bulletin 160 to the

FIGURE ES4-2

California Wild and Scenic Rivers

TABLE ES4-8

Instream Flow Requirements by Hydrologic Region (taf)

Region	1995 Average	1995 Drought	2020 Average	2020 Drought
North Coast	1,410	1,285	1,410	1,285
San Francisco Bay	17	9	17	9
Central Coast	20	9	20	9
South Coast	4	4	4	4
Sacramento River	3,397	2,784	3,397	2,784
San Joaquin River	1,169	712	1,169	712
Tulare Lake	0	0	0	0
North Lahontan	85	84	85	84
South Lahontan	107	81	107	81
Colorado River	0	0	0	0
Total (rounded)	**6,210**	**4,970**	**6,210**	**4,970**

applied water budgets used in Bulletin 160-98 created a challenge in properly accounting for multiple instream flows within a river basin. Bulletin 160-98 used a simplified approach in which only the largest downstream flow requirement was included in the water budgets. This simplified approach undercounts applied instream flow requirements on streams having multiple requirements. The Department is developing a new modeling approach for the next water plan update that will more accurately quantify applied instream flows.

Since the determination of 1990-level instream flow values used as base conditions in Bulletin 160-93, subsequent agreements or decisions have increased or added instream flow requirements for the Trinity River, Mokelumne River, Stanislaus River, Tuolumne River, Owens River, Putah Creek, and Mono Lake tributaries. In addition, ten new waterways have been added to the Bulletin 160-98 instream flow water budgets—the Mad River, Eel River, Russian River, Truckee River, East Walker River, Nacimiento River, San Joaquin River (at Vernalis), Walker Creek, Lagunitas Creek, and Piru Creek.

Table ES4-8 shows instream flows used in Bulletin 160-98 water budgets by hydrologic region. The drought year scenario shown in the tables represents the minimum annual required flow volume. For average water years, the annual required flow volume is computed by combining the expected number of years in each year type (wet, above normal, normal, below normal, and/or dry, as specified in existing agreements or orders).

Bay-Delta Outflow

Environmental water use for Bay-Delta outflow is computed by using operations studies to quantify SWRCB Order WR 95-6 requirements. Order WR 95-6 established numerical objectives for salinity, river flows, export limits, and Delta outflow. Operations studies were used to translate these numerical objectives into Delta outflow requirements for average and drought year scenarios. The studies computed outflow requirements of approximately 5.6 maf in average years and 4.0 maf in drought years.

Wetlands

The wetlands component of environmental water use is based on water use at freshwater managed wetlands, such as federal national wildlife refuges and State wildlife management areas. In general, wetlands can be divided into saltwater and brackish water marshes (usually located in coastal areas) and freshwater wetlands (generally located in inland areas).

Five areas of California contain the largest remaining wetlands acreage in the State—the Central Valley, Humboldt Bay, San Francisco Bay, Suisun Marsh, and Klamath Basin. The majority of the State's wetland protection and restoration efforts are occurring in these areas. Nontidal wetlands usually depend on a supplemental water supply, and protecting or restoring them may create demands for freshwater supplies.

Bulletin 160-98 quantifies applied water needs only for managed wetlands, because other wetlands types such as vernal pools or coastal wetlands use naturally-occurring water supply (precipitation or tidal action). Managed wetlands are defined for the Bulletin as impounded freshwater and nontidal brackish water wetlands. Managed wetlands may be State and federal wildlife areas or refuges, private wetland preserves owned by nonprofit organizations,

TABLE ES4-9

Wetlands Water Use by Hydrologic Region (taf)

Region	1995		2020	
	Average	*Drought*	*Average*	*Drought*
North Coast	325	325	325	325
San Francisco Bay	160	160	160	160
Central Coast	0	0	0	0
South Coast	27	27	31	31
Sacramento River	632	632	632	632
San Joaquin River	230	230	240	240
Tulare Lake	50	50	53	53
North Lahontan	18	18	18	18
South Lahontan	0	0	0	0
Colorado River	39	38	44	43
Total (rounded)	**1,480**	**1,480**	**1,500**	**1,500**

TABLE ES4-10

Applied Environmental Water Use by Hydrologic Region (taf)

Region	1995		2020	
	Average	*Drought*	*Average*	*Drought*
North Coast	19,544	9,518	19,545	9,518
San Francisco Bay	5,762	4,294	5,762	4,294
Central Coast	118	37	118	37
South Coast	100	82	104	86
Sacramento River	5,833	4,223	5,839	4,225
San Joaquin River	3,396	1,904	3,411	1,919
Tulare Lake	1,672	809	1,676	813
North Lahontan	374	256	374	256
South Lahontan	107	81	107	81
Colorado River	39	38	44	43
Total (rounded)	**36,940**	**21,240**	**36,980**	**21,270**

private duck clubs, or privately owned agricultural lands flooded for cultural practices such as rice straw decomposition. Some of the largest concentrations of privately owned wetlands are the duck clubs in the Suisun Marsh and the flooded rice fields in the Sacramento Valley. (Acreage of rice fields flooded to enhance decomposition of stubble remaining after harvest and to provide habitat for overwintering waterfowl was identified by Department land use surveys.) Table ES4-9 shows wetlands water demands by region.

Summary of Environmental Water Use

Table ES4-10 shows base 1995 and forecasted 2020 environmental water use by hydrologic region. The large values in the North Coast Region illustrate the magnitude of demands for wild and scenic rivers in comparison to other environmental water demands.

Water Use Summary by Hydrologic Region

Tables ES4-11 and ES4-12 summarize California's average and drought year applied water use by hydrologic region. The tables combine the urban, agricultural, and environmental water use described in this chapter. Also included are related minor uses such as conveyance losses and self-supplied industrial and powerplant cooling water. These demands, together with the water supply information presented in Chapter ES3, are used to prepare the statewide water balance shown in Chapter ES5 and the regional water balances shown in Appendix ES5A.

TABLE ES4-11

California Average Year Water Use by Hydrologic Region (taf)

Region	1995 Urban	1995 Agricultural	1995 Environmental	1995 Total (rounded)	2020 Urban	2020 Agricultural	2020 Environmental	2020 Total (rounded)
North Coast	169	894	19,544	20,610	201	927	19,544	20,670
San Francisco Bay	1,255	98	5,762	7,110	1,317	98	5,762	7,180
Central Coast	286	1,192	118	1,600	379	1,127	118	1,620
South Coast	4,340	784	100	5,220	5,519	462	104	6,080
Sacramento River	766	8,065	5,833	14,660	1,139	7,939	5,839	14,920
San Joaquin River	574	7,027	3,396	11,000	954	6,450	3,411	10,820
Tulare Lake	690	10,736	1,672	13,100	1,099	10,123	1,676	12,900
North Lahontan	39	530	374	940	50	536	374	960
South Lahontan	238	332	107	680	619	257	107	980
Colorado River	418	4,118	39	4,570	740	3,583	44	4,370
Total (rounded)	**8,770**	**33,780**	**36,940**	**79,490**	**12,020**	**31,500**	**36,980**	**80,500**

TABLE ES4-12

California Drought Year Water Use by Hydrologic Region (taf)

Region	1995 Urban	1995 Agricultural	1995 Environmental	1995 Total (rounded)	2020 Urban	2020 Agricultural	2020 Environmental	2020 Total (rounded)
North Coast	177	973	9,518	10,670	212	1,011	9,518	10,740
San Francisco Bay	1,358	108	4,294	5,760	1,428	108	4,294	5,830
Central Coast	294	1,279	37	1,610	391	1,223	37	1,650
South Coast	4,382	820	82	5,280	5,612	484	86	6,180
Sacramento River	830	9,054	4,223	14,110	1,236	8,822	4,225	14,280
San Joaquin River	583	7,244	1,904	9,730	970	6,719	1,919	9,610
Tulare Lake	690	10,026	809	11,530	1,099	9,532	813	11,440
North Lahontan	40	584	256	880	51	594	256	900
South Lahontan	238	332	81	650	619	257	81	960
Colorado River	418	4,118	38	4,570	740	3,583	43	4,370
Total (rounded)	**9,010**	**34,540**	**21,240**	**64,790**	**12,360**	**32,330**	**21,270**	**65,960**

5

Executive Summary

Balancing Supply and Demand

This chapter assesses California's water future, based on today's conditions and on options being considered by California's water purveyors. The Department's Bulletin 160 series does not forecast a particular vision for the future, but instead attempts to forecast the future based on today's data, economic conditions, and public policies.

Although no forecast of the future can be perfect, several key trends appear inevitable. California's population will increase dramatically by 2020. How growth is accommodated and the land use planning decisions made by cities and counties have important implications for future urban and agricultural water use. California's agricultural acreage is forecasted to decline slightly by 2020 (reflecting the State's increasing urbanization), as is its agricultural water use. (California agriculture is still anticipated to lead the nation's agricultural production because of advantages such as climate and proximity to domestic and export markets.) As the State's population expands, greater attention will be directed to preserving and restoring California ecosystems and to maintaining the natural resources which have attracted so many people to California.

The 1848 discovery of gold at Sutter's Mill on the American River led to California's statehood in 1850. California celebrates its sesquicentennial in 2000.

Miners in the Sierra, *Detail of painting by Charles Nahl and Frederick Wenderoth, 1851.*

Courtesy of Smithsonian Institution

This chapter begins by reviewing water supply and demand information and the statewide applied water budget with existing facilities and programs. Water management options identified as likely to be implemented are then tabulated and included in a statewide applied water budget with options. The chapter ends with an evaluation of how actions planned by water purveyors statewide would affect forecasted water shortages, and then summarizes key findings.

Future with Existing Facilities and Programs

Table ES5-1 shows the California water budget with existing facilities and programs. Regional water budgets with existing facilities and programs are shown in Appendix ES5A.

Water Supply

As described in Chapter ES3, average annual statewide precipitation over California's land surface is about 200 maf. About 65 percent of this precipitation is consumed through evaporation and transpiration by California's forests, grasslands, and vegetation. The remaining 35 percent comprises the State's average annual intrastate runoff of about 71 maf. Over 30 percent of this runoff is not explicitly designated for urban, agricultural, or environmental uses.

The State's 1995-level average water year applied water supply—from intrastate sources, interstate sources, and return flows—is about 78 maf. Even assuming a reduction in Colorado River supplies to California's 4.4 maf basic apportionment, average year statewide supply is projected to increase 0.2 maf by 2020 without additional water supply options. This projected increase in water supply is due mainly to higher CVP and SWP deliveries in response to higher 2020 level demands. Additional groundwater extraction and facilities now under construction will also provide new supplies. The State's 1995-level drought year supply is about 60 maf. Drought year supply is projected to increase slightly by 2020 without future water supply options, for the same reasons that average year supplies are expected to increase.

Bulletin 160-98 estimates statewide groundwater overdraft of about 1.5 maf/yr at a 1995 level of development. Increasing overdraft in the 1990s reverses the trend of basin recovery seen in the 1980s. Most increases are occurring in the San Joaquin and Tulare Lake regions, due primarily to Delta export restrictions associated with the SWRCB Order WR 95-6, ESA requirements, and reductions in CVP supplies.

Water recycling is a small, yet growing, element of California's water supply. At a 1995 level of development, water recycling and desalting produce about 0.3 maf/yr of new water (reclaiming water that would otherwise flow to the ocean or to a salt sink), up significantly from the 1990 annual supply of new water. The California Water Code urges wastewater treatment agencies located in coastal areas to recycle as much of their treated effluent as possible, recognizing that this water supply would otherwise be lost to the State's hydrologic system. Greater recycled water production at existing treatment plants and additional production at plants now under construction are ex-

TABLE ES5-1

California Water Budget with Existing Facilities and Programs (maf)

	1995		*2020*	
	Average	*Drought*	*Average*	*Drought*
Water Use				
Urban	8.8	9.0	12.0	12.4
Agricultural	33.8	34.5	31.5	32.3
Environmental	36.9	21.2	37.0	21.3
Total	**79.5**	**64.7**	**80.5**	**66.0**
Supplies				
Surface Water	65.1	43.5	65.0	43.4
Groundwater	12.5	15.8	12.7	16.0
Recycled and Desalted	0.3	0.3	0.4	0.4
Total	**77.9**	**59.6**	**78.1**	**59.8**
Shortage	**1.6**	**5.1**	**2.4**	**6.2**

pected to increase new recycled and desalted supplies by nearly 30 percent to 0.4 maf/yr by 2020.

Water Demand

California's estimated demand for water at a 1995 level of development is about 80 maf in average years and 65 maf in drought years. California's water demand in 2020 is forecasted to reach 81 maf in average years and 66 maf in drought years. California's increasing population is a driving force behind increasing water demands.

California's population is forecasted to increase to 47.5 million people by 2020 (about 15 million people more than the 1995 base). Forty-six percent of the State's population increase is expected to occur in the South Coast Region. Even with extensive water conservation, urban water demand will increase by about 3.2 maf in average years. (Bulletin 160-98 assumes that all urban and agricultural water agencies will implement BMPs and EWMPs by 2020, regardless of whether they are cost-effective for water supply purposes.)

Irrigated crop acreage is expected to decline by 325,000 acres—from the 1995 level of 9.5 million acres to a 2020 level of 9.2 million acres. Reductions in forecasted irrigated acreage are due primarily to urban encroachment and to impaired drainage on lands in the western San Joaquin Valley. Increases in water use efficiency combined with reductions in irrigated acreage are expected to reduce average year agricultural water demand by about 2.3 maf by 2020. Shifts from lower to higher value crops are expected to continue, with an increase in permanent plantings such as orchards and vineyards. This trend would tend to harden agricultural demands associated with permanent plantings, making it less likely that this acreage would be temporarily fallowed during droughts.

Average and drought year water needs for environmental use are forecasted to increase by about 0.1 maf by 2020. Drought year environmental water needs are considerably lower than average year environmental water needs, reflecting the variability of unimpaired flows in wild and scenic rivers. North Coast wild and scenic rivers constitute the greatest component of environmental water demands. CVPIA implementation, Bay-Delta requirements, new ESA restrictions, and FERC relicensing could significantly modify environmental demands within the Bulletin 160-98 planning period.

Water Shortages

The shortage shown in Table ES5-1 for 1995 average water year conditions reflects the Bulletin's assumption that groundwater overdraft is not available as a supply. Forecasted water shortages vary widely from region to region, as presented in Figure ES5-1. For example, the North Coast and San Francisco Bay Regions are not expected to experience future shortages during average water years but are expected to see shortages in drought years. Most of the State's remaining regions experience average year and drought year shortages now, and are forecasted to experience increased shortages in 2020. The largest future shortages are forecasted for the Tulare Lake and South Coast Regions, areas that rely heavily on imported water supplies. These regions of the State are also where some of the greatest increases in population are expected to occur.

The shortages shown in Figure ES5-1 highlight the need for future water management actions to reduce the gap between forecasted supplies and demands. As Californians experienced during the most recent drought (especially in 1991 and 1992), drought year shortages are large. Urban residents faced cutbacks in supply and mandatory rationing, some small rural communities saw their wells go dry, agricultural lands were fallowed, and environmental water supplies were reduced. By 2020, without additional facilities and programs, these conditions will worsen.

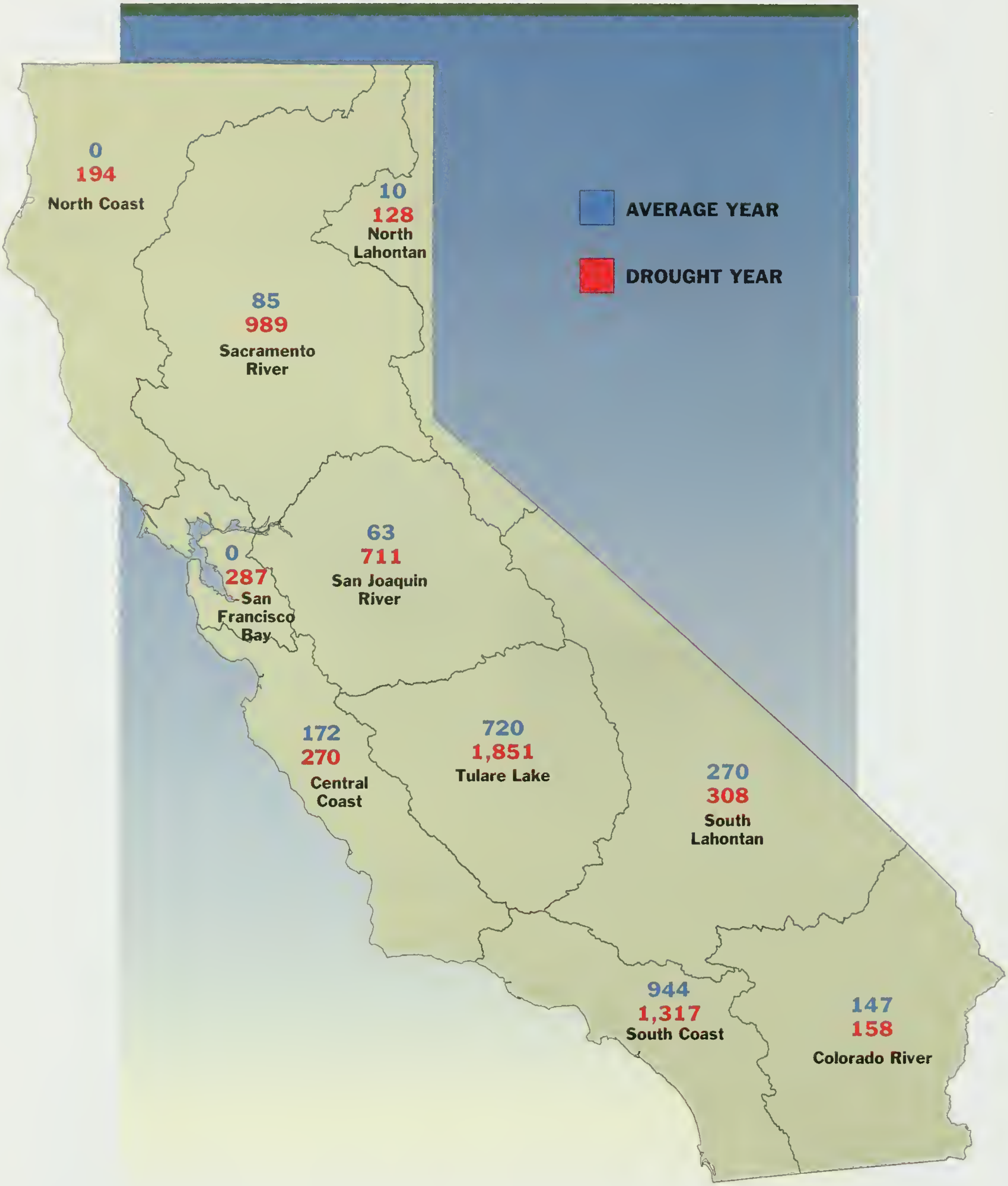
Future water shortages have direct and indirect economic consequences. Direct consequences include costs to residential water users to replace landscaping lost during droughts, costs to businesses that experience water supply cutbacks, or costs to growers who fallow land because supplies are not available. Indirect consequences include decisions by businesses and growers not to locate or to expand their operations in California, and reductions in the value of agricultural lands. Other consequences of shortages are less easily measured in economic terms—loss of recreational activities or impacts to environmental resources, for example.

The Bulletin 160-98 Planning Process

At an appraisal level of detail, the Bulletin draws upon integrated resources planning techniques to evaluate alternatives for meeting California's future water needs. IRP evaluates water management options—both demand reduction options and supply

FIGURE ES5-1

2020 Shortages by Hydrologic Region with Existing Facilities and Programs (taf)



augmentation options—against a fixed set of criteria and ranks the options based on costs and other factors. Although the IRP process includes economic evaluations, it also incorporates environmental, institutional, and social considerations which cannot be expressed easily in monetary terms.

The development of likely regional water management options uses information prepared by local agencies. The regional water management options evaluations are not intended to replace local planning efforts, but to complement them by showing the relationships among regional water supplies and water needs and the statewide perspective. Local water management options form the basis of the regional summaries which are combined into the statewide options evaluation.

Major Steps in Planning Process

The major steps involved in the Bulletin 160-98 water management options evaluation process included:

- Identify water demands and existing water supplies on a regional basis.
- Compile comprehensive lists of regional and statewide water management options.
- Use initial evaluation criteria to either retain or defer options from further evaluation. For options retained for further evaluation, some were grouped by categories and others were evaluated individually.
- Identify characteristics of options or option categories, including costs, potential demand reduction or supply augmentation, environmental considerations, and significant institutional issues.
- Evaluate each regional option or category of options in light of identified regional characteristics using criteria established for this Bulletin. If local agencies have performed their own evaluation, review and compare their evaluation criteria with those used for the Bulletin.
- Evaluate statewide water management options.
- Develop tabulation of likely regional water management options.
- Develop a statewide options evaluation by integrating the regional results.

The first step in evaluating the regional water management options was to prepare applied water budgets for the study areas to identify the magnitude of potential water shortages for average and drought year conditions. In addition to identifying shortages, other water supply reliability issues in the region were identified. Once the shortages were identified, a list of local water management options was prepared. Where possible, basic characteristics of these options (e.g., yields, cost data, significant environmental or institutional concerns) were identified.

After the options were identified, they were compared with the initial screening criteria shown in the sidebar. For options deferred from further evaluation, the major reasons for deferral were given. Options retained for further evaluation were categorized (some options within each category were further combined into groups based upon their estimated costs) and were evaluated and scored against the set of fixed criteria shown in the options category evaluation sidebar.

The Bulletin 160-98 options evaluation process relied heavily upon locally developed information.

Initial Screening Criteria

The criteria used for initial screening of water management options were:

- Engineering—an option was deferred from further evaluation if it was heavily dependent on the development of technologies not currently in use, it used inappropriate technologies given the regional characteristics (e.g., desalting in the North Lahontan Region), or it did not provide new water (e.g., water recycling in the Central Valley).
- Economic—an option was deferred from further evaluation if its cost estimates (including environmental mitigation costs) were extraordinarily high given the region's characteristics.
- Environmental—an option was deferred from further evaluation if it had potentially significant unmitigable environmental impacts or involved use of waterways designated as wild and scenic.
- Institutional/Legal—an option was deferred from further evaluation if it had potentially unresolvable water rights conflicts or conflicts with existing statutes.
- Social/Third Party—an option was deferred from further evaluation if it had extraordinary socioeconomic impacts, either in the water source or water use areas.
- Health—an option was deferred from further evaluation if it would violate current health regulations or would pose significant health threats.

Options Category Evaluation

Evaluation Criteria	*What is Measured?*	*How is it Measured?*	*Score*
Engineering	Engineering feasibility	Increase score for greater reliance upon current technologies	
	Operational flexibility	Increase score for operational flexibility with existing facilities and/or other options	
	Drought year supply	Increase score for greater drought year yield/ reliability	
	Implementation date	Increase score for earlier implementation date	
	Water quality limitations	Increase score for fewer water quality constraints	
Engineering Score			0 - 4
Economics	Project financial feasibility	Increase score for lower overall costs and the ability to finance	
	Project unit cost	Increase score for lower overall unit cost (including mitigation costs)	
Economics Score			0 - 4
Environmental	Environmental risk	Increase score for least amount of environmental risk	
	Irreversible commitment of resources	Increase score for least amount of irreversible commitment of resources	
	Collective impacts	Increase score for least amount of collective impacts	
	Proximity to environmentally sensitive resources	Increase score for little or no proximity to sensitive resources	
Environmental Score			0 - 4
Institutional/Legal	Permitting requirements	Increase score for least amount of permitting requirements	
	Adverse institutional/legal effects upon water source areas	Increase score for least amount of adverse institutional/legal effects	
	Adverse institutional/legal effects upon water use areas	Increase score for least amount of adverse institutional/legal effects	
	Stakeholder consensus	Increase score for greater amount of stakeholder consensus	
Institutional/Legal Score			0 - 4
Social/Third Party	Adverse third party effects upon water source areas	Increase score for least amount of adverse third party effects	
	Adverse third party effects upon water use areas	Increase score for least amount of adverse third party effects	
	Adverse social and community effects	Increase score for least amount of adverse social and community effects	
Social/Third Party Score			0 - 4
Other Benefits	Ability to provide benefits in addition to water supply	Increase score for environmental benefits	
		Increase score for flood control benefits	
		Increase score for recreation benefits	
		Increase score for energy benefits	
		Increase score for additional benefits	
		Increase score for improved compliance with health and safety regulations	
Other Benefits Score			0 - 4
Total Score			0 - 24

Methods used to develop this information vary from one local agency to the next, thus making direct comparisons between cost estimates difficult. To make cost information comparable, a common approach for estimating unit cost (cost per acre-foot) was developed for this Bulletin. Where project information was readily available, costs were normalized using this approach. However, due to time constraints and lack of detailed information, not all option costs were normalized. Option unit cost estimates took into account capital costs associated with construction and implementation, including any needed conveyance facilities, and annual operations, maintenance, and replacement costs.

Water management options can serve purposes other than water supply; they can also provide flood control, hydroelectric power generation, environmental enhancement, water quality enhancement, and recreation. In recognition of the multipurpose benefits provided by some water management options, the options evaluation scoring process assigned a high value to multipurpose options, as shown in the sidebar. However, since the focus of the Bulletin 160 series is water supply, cost estimates were based solely on the costs associated with water supply.

Once options had been evaluated and scored, they were ranked according to their scores. This ranking was used to prepare a tabulation of likely regional water management options, taking into account options that might be mutually exclusive or could be optimized if implemented in conjunction with other options. Depending on a region's characteristics, its potential options, and its ability to pay for new options, the tabulation of likely options might not meet all of a region's water shortages (especially in drought years). In regions where options do not meet all shortages, the economic costs of accepting shortages would be less than the costs of acquiring additional water supplies through the options identified in this Bulletin.

This appraisal-level evaluation of options at a statewide level of detail is based on the information presently available. The ultimate implementability of any water management option is dependent on factors such as the sponsoring entity's ability to complete the appropriate environmental documentation, obtain the necessary permits, and finance the proposed action.

Shortage Management

Water agencies may choose to accept less than 100 percent water supply reliability, especially under drought conditions, depending on the characteristics of their service areas. Shortage contingency measures, such as restrictions on residential outdoor watering or deficit irrigation for agricultural crops, can be used to help respond to temporary shortages. However, demand hardening is an important consideration in evaluating shortage contingency measures. Implementing water conservation measures such as plumbing retrofits and low water use landscaping reduces the ability of water users to achieve future drought year water savings through shortage contingency measures.

The impacts of allowing planned shortages to occur in water agency service areas are necessarily site-specific, and must be evaluated by each agency on an individual basis. In urban areas where conservation measures have already been put into place to reduce landscape water use, imposing rationing or other restrictions on landscape water use can create significant impacts to homeowners, landscaping businesses, and entities that manage large turf areas such as parks and golf courses. Drought year cutbacks in the agricultural sector create economic impacts not only to individual growers and their employees, but also to local businesses that provide goods and services to the growers.

Using Applied Water Budgets to Calculate New Water Needs

Some municipal wastewater discharges, agricultural return flows, and required environmental instream flows are reapplied several times before finally being depleted from the State's hydrologic system. An applied water budget explicitly accounts for this unplanned reuse of water. Because reapplication has the potential to account for a substantial portion of a region's water supply, applied water budgets may overstate the supply of water actually needed to meet future water demands. Therefore, shortages calculated from an applied water budget must be interpreted with caution to determine new water needs for a region.

The amount of new water required to meet a region's future needs depends on several factors, including the region's applied water shortage, opportunities to reapply water in the region, and the types of water management options that are implemented in the region. If no water reapplication opportunities exist, then the region's new water need is equivalent to its applied water shortage. In this extreme case, the new water need would be independent of the types of water management options that are implemented. However, if opportunities are available to reapply water in a region, then the region's new water need is less than its applied water shortage. In this case, the new water need depends on the types of water management options that are implemented.

Not all water management options are created equal in their ability to meet new water needs. Because supply augmentation options provide new water to a region, the opportunity exists for the options' effectiveness to be multiplied through reapplication. For example, a supply augmentation option may provide 100 taf of new water to a region. But through reapplication within the region, the option effectively meets applied water demands in excess of 100 taf. Demand reduction options, on the other hand, do not provide new water to a region. Hence, the opportunity does not exist to multiply the options' effectiveness through reapplication. To satisfy an applied water shortage of 100 taf, a demand reduction option must conserve 100 taf of water.

Based on the above discussion, calculation of regional and statewide new water needs is more complex than computing regional and statewide applied water shortages—new water needs also depend on reapplication and implemented water management options. An applied water shortage provides an upper bound on the new water need. A lower bound on the new water need can be estimated for each region by assuming that new water supplies are reapplied in the same proportion that existing supplies are reapplied.

The tabulations of likely regional water management options utilize minimum new water needs (rather than applied water shortages) as target values for selecting the appropriate number of regional options. If a region is unable to meet minimum new water needs as a result of regional characteristics, lack of potential options, or inability to pay for potential options, specifying minimum new water needs rather than applied water shortages as regional target values has no impact on options selection. On the other hand, if a region is able to meet its minimum new water needs, this does not necessarily guarantee that all applied water shortages would be met. The remaining applied water shortages would depend on the selected option mix—the more water conservation selected, the greater the remaining applied water shortages would be (as water conservation options do not provide reapplication opportunities.) This approach is consistent with Bulletin 160-93, which used net water shortages as target values for selecting regional options. Because data in net water budgets factor out reapplied water, net water shortages are essentially the same as minimum new water needs.

Summary of Options Likely to be Implemented

The options summarized in this section represent water purveyors' strategies for meeting future needs. This information relies heavily on actions identified by local water agencies, which collectively provide about 70 percent of the State's developed water supply. As described earlier, water management options likely to be implemented were selected based on a ranking process that evaluated factors such as technical feasibility, cost, and environmental considerations. This process is most effective in hydrologic regions where local agencies have prepared plans for meeting future needs in their service areas. Affordability is a key factor for local agencies in deciding the extent to which they wish to invest in alternatives to improve their water service reliability. Water agencies must balance costs and quantity of supply (and sometimes quality of supply) based on their service area needs.

The Bulletin 160 series focuses on water supply. The statewide compilation of likely options has not been tailored to meet other water-related objectives such as flood control, hydropower generation, recreation, or nonpoint source pollution control. The evaluation process used to select likely options rated the options based on their ability to provide multiple benefits, as described in the previous section.

Options shown in Table ES5-2 include demand reduction beyond BMP and EWMP implementation included in Table ES5-1. Future demand reduction options are options that would produce new water supply through reduction of depletions. For these optional water conservation measures to have been identified as likely, they must be competitive in cost with water supply augmentation options.

Local supply augmentation options comprise the largest potential new source of drought year water for California. (Local options include implementation of the draft CRB 4.4 Plan to reduce California's use of Colorado River water.) In Table ES5-2 and in the water budgets, only water marketing options that result in a change of place of use of the water (from one hydrologic region to another), or a change in type of use (e.g., agricultural to urban) have been included. Considerably more marketing options are described in the Bulletin than are shown in the water budgets, reflecting local agencies' plans to purchase future supplies

TABLE ES5-2

Summary of Options Likely to be Implemented by 2020, by Option Type (taf)

Option Type	*Average*	*Drought*
Local Demand Reduction Options	507	582
Local Supply Augmentation Options		
Surface Water	110	297
Groundwater	24	539
Water Marketing	67	304
Recycled and Desalted	423	456
Statewide Supply Options		
CALFED Bay-Delta Program	100	175
SWP Improvements	117	155
Water Marketing (Drought Water Bank)	—	250
Multipurpose Reservoir Projects	710	370
Expected Reapplication	141	433
Total Options	**2,199**	**3,561**

from sources yet to be identified. Where the participants in a proposed transfer are known, the selling region's average year or drought year supply has been reduced in the water budgets. Presently, the only transfers with identified participants that are large enough to be visible in the water budgets are those associated with the draft CRB 4.4 Plan. Water agencies' plans to acquire water through marketing arrangements will depend on their ability to find sellers and on the level of competition for water purchases among water agencies and environmental restoration programs (such as CVPIA's AFRP or CALFED's ERP).

Possible statewide options include actions that could be taken by CALFED to develop new water supplies. The timing and extent of new water supplies that CALFED might provide are uncertain at the time of the Bulletin's printing, since CALFED has not identified a draft preferred alternative and a firm schedule for its implementation. CALFED's current schedule calls for a first phase of program implementation spanning seven to ten years, at the end of which time a final decision would be made about the extent of any storage and conveyance facilities that might be constructed. Given the long lead time required for implementing large storage projects, no CALFED facilities may be in service within the Bulletin's 2020 planning horizon.

Bulletin 160-98 uses a placeholder analysis for new CALFED water supply development to illustrate the potential magnitude of new water supply the program might provide. The placeholder does not address specifics of which surface storage facilities might be selected, since this level of detail is not available.

Other statewide options include specific projects to improve SWP water supply reliability, the State's drought water bank, and two multipurpose reservoirs. A third potential multipurpose reservoir option, an enlarged Shasta Lake, was recommended for further study because additional work is needed to quantify benefits and costs associated with different reservoir sizes.

The two multipurpose reservoir projects included as statewide options—Auburn Reservoir and enlarged Millerton Lake—were included to emphasize the interrelationship between water supply needs and the Central Valley's flood protection needs. Each reservoir would offer significant flood protection benefits. Both projects have controversial aspects, and neither of them is inexpensive. However, they merit serious consideration.

The potential future water management options summarized in this section are still being planned. Their implementation is subject to completion of environmental documents, permit acquisition, and compliance with regulatory requirements such as those of ESA. These processes will address mitigating environmental impacts and resolving third-party impacts. If water management options are delayed or rendered infeasible as a result of these processes, or if their costs are increased to the point that the options are no longer affordable for the local sponsors, statewide shortages will be correspondingly affected.

Floodflows on the American River in 1986 breached the cofferdam that USBR had constructed when it began its initial work at the Auburn damsite. This flood event produced record flows in the American River through metropolitan Sacramento.

Implementing Future Water Management Options

Table ES5-3 was developed by combining the regional and statewide analyses of water management options with the water budget with existing facilities and programs (Table ES5-1). Table ES5-3 illustrates the effect these options would have on forecasted future shortages. (Appendix ES5B shows regional water budgets with option implementation.) The table indicates that water management options now under consideration by water purveyors throughout the State will not reduce shortages to zero in 2020. The difference between average water year and drought year water shortages is significant. Water purveyors generally consider shortages in average years as basic deficiencies that should be corrected through long-term demand reduction or supply augmentation measures. Shortages in drought years may be managed by such long-term measures in combination with short-term actions used only during droughts. Short-term measures could include purchases from the State's drought water bank, urban water rationing, or agricultural land fallowing. Agencies may evaluate the marginal costs of developing new supplies and conclude that the cost of their development exceeds that of shortages to their service areas, or exceeds the cost of implementing contingency measures such as transfers or rationing. As water agencies implement increasing amounts of water conservation in the future (especially plumbing fixture changes), there will be a correspondingly lessened ability to implement short-term drought response actions such as rationing. Demand hardening will influence agencies' decisions about their future mix of water management actions.

Ability to pay is another consideration. Large urban water agencies frequently set high water service reliability goals and are able to finance actions necessary to meet the goals. Agencies supplying small rural communities may not be able to afford expensive projects. Small communities have limited populations over which to spread capital costs and may have difficulty obtaining financing. If local groundwater resources are inadequate to support expected growth, these communities may not be able to afford projects such as pipelines to bring in new surface water supplies. Small rural communities that are geographically isolated from population centers cannot readily interconnect with other water systems.

Agricultural water agencies may be less able to pay for capital improvements than urban water agencies. Much of the State's earliest large-scale water development was for agriculture, and irrigation works were constructed at a time when water development was inexpensive by present standards. Agricultural users today may not be able to compete with urban users for development of new supplies. Some agricultural water users have historically been willing to accept lower water supply reliability in return for less expensive water supplies. It may be less expensive for some agricultural users to idle land in drought years rather

TABLE ES5-3

California Water Budget with Options Likely to be Implemented (maf)

	1995		2020	
	Average	*Drought*	*Average*	*Drought*
Water Use				
Urban	8.8	9.0	11.8	12.1
Agricultural	33.8	34.5	31.3	32.1
Environmental	36.9	21.2	37.0	21.3
Total	**79.5**	**64.7**	**80.1**	**65.5**
Supplies				
Surface Water	65.1	43.5	66.4	45.4
Groundwater	12.5	15.8	12.7	16.5
Recycled and Desalted	0.3	0.3	0.8	0.9
Total	**77.9**	**59.6**	**79.9**	**62.8**
Shortage	**1.6**	**5.1**	**0.2**	**2.7**

than to incur capital costs of new water supply development. This can be particularly true for regions faced with production constraints such as short growing seasons or lower quality lands—areas where the dominant water use may be irrigated pasture. In areas such as the North Lahontan Region, for example, local agencies generally do not have plans for new programs or facilities to reduce agricultural water shortages in drought years. Figure ES5-2 shows forecasted shortages by hydrologic region to illustrate the effects of option implementation on a regional basis.

Local agencies that expect to have increased future demands generally do more water supply planning than do agencies whose demands remain relatively level. Most agricultural water agencies are not planning for greater future demands, although some agencies are examining ways to improve reliability of their existing supplies. Cost considerations limit the types of options available to many agricultural users. The agricultural sector has thus developed fewer options that could be evaluated in statewide water supply planning. Many options have been generated from planning performed by urban agencies, reflecting Urban Water Management Planning Act requirements that urban water suppliers with 3,000 or more connections, or that deliver over 3 taf/yr, prepare plans showing how they will meet service area needs.

Geography plays a role in the feasibility of implementing different types of options, and not solely with respect to the availability of surface water and groundwater supplies. Water users in the Central Valley, Bay Area, and Southern California having access to major regional conveyance facilities have greater opportunities to rely on water marketing arrangements and conjunctive use options than do water users isolated from the State's main water infrastructure.

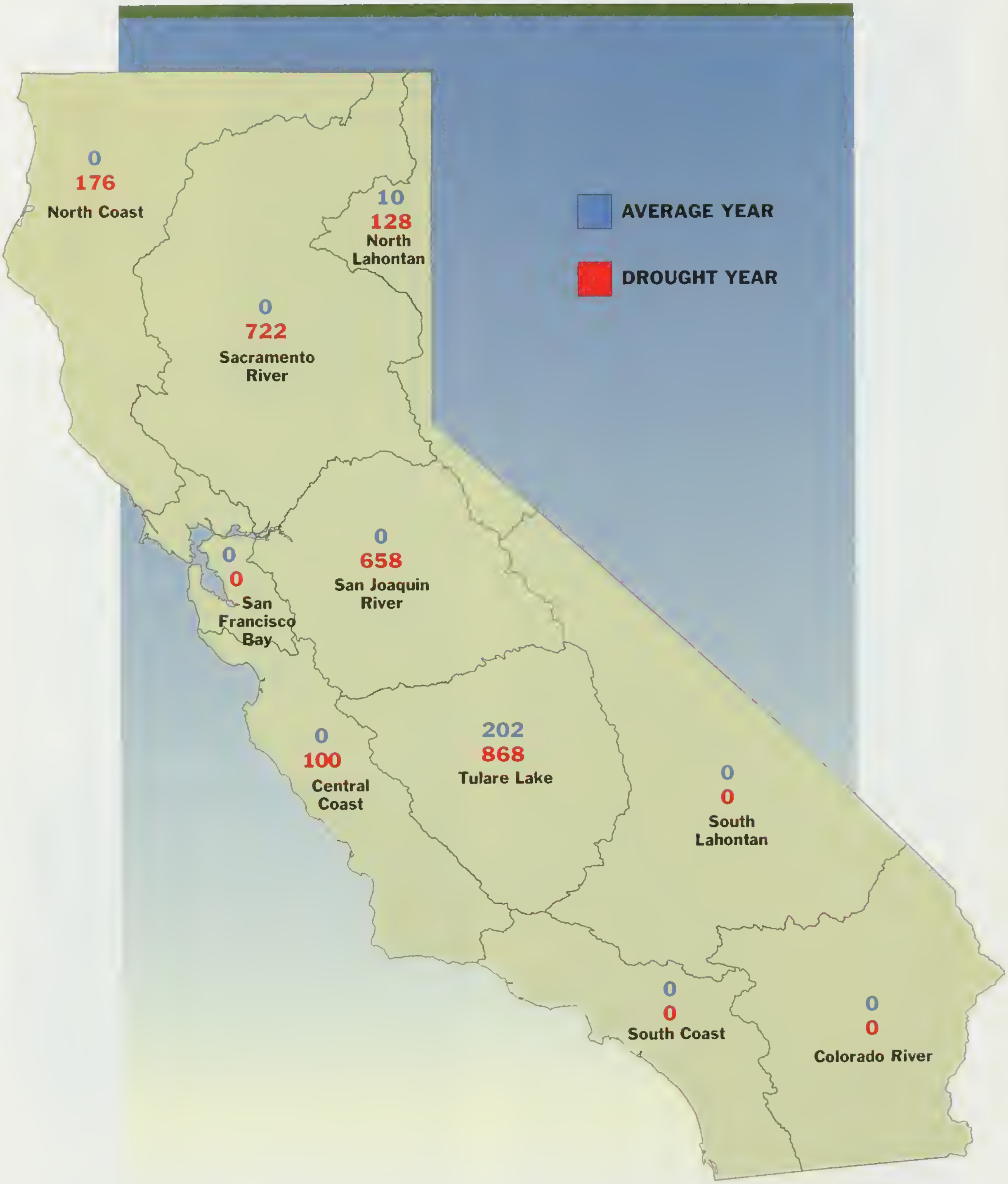
Bulletin 160-98 Findings

Bulletin 160-98 forecasts water shortages in California by 2020, as did the previous water plan update. The water management options identified in the Bulletin as likely to be implemented by 2020 would reduce, but not completely eliminate future shortages. Water agencies faced with meeting future needs must determine how those needs can be met within the statutory and regulatory framework affecting water use decisions, including how the needs can be met in a manner equitable to existing water users. Land use planning decisions made by cities and counties—locations where

Options identified as likely are still in the planning stages. Agencies implementing the options must complete environmental documentation and obtain the necessary permits. The permitting and environmental documentation process must consider impacts to listed species such as this San Joaquin Valley kit fox.

FIGURE ES5-2

2020 Shortages by Hydrologic Region with Likely Options (taf)



future growth will or will not be allowed, housing densities, preservation goals for open space or agricultural reserves—will have a significant influence on California's future water demands. Good coordination among local land use planning agencies and water agencies, as well as among water agencies themselves at a regional level, will facilitate finding solutions to meeting future needs.

Bulletin 160-98 makes no specific recommendations regarding how California water purveyors should meet the needs of their service areas, because it is the water purveyors who are responsible for meeting those needs. The purpose of Bulletin 160-98 is to predict future water needs based on today's conditions. Clearly, different agencies and individuals have different perspectives about how the future should be shaped. The CALFED discussions, for example, illustrate conflicting values among individuals and agencies.

There is not one magic bullet for meeting California's future water needs—not new reservoirs, not new conveyance facilities, not more groundwater extraction, not more water conservation, not more water recycling. Each of these options has its place. The most frequently used methods of providing new water supplies have changed with the times, reflecting changing circumstances. Much of California's early water development was achieved by constructing reservoirs and diverting surface water. Advances in technology, in the form of deep well turbine pumps, subsequently allowed substantial groundwater development. More recent improvements in water treatment technology have made water recycling and desalting feasible options. Today, water purveyors have an array of water management options available to meet future water supply reliability needs. The magnitude of potential shortages, especially drought year shortages, demonstrates the urgency of taking action. The do-nothing alternative is not an alternative that will meet the needs of 47.5 million Californians in 2020.

California water agencies have made great strides in water conservation since the 1976-77 drought. Bulletin 160-98 forecasts substantial demand reduction from implementing presently identified urban BMPs and agricultural EWMPs, and assumes a more rigorous level of implementation than water agencies are now obligated to perform. Presently, about half of California's urban population is served by retailers that have signed the urban memorandum of understanding for water conservation measures. Less than one-third of California's agricultural lands are served by agencies that have signed the corresponding agricultural MOU. Bulletin 160-98 assumes that all water purveyors statewide will implement BMPs and EWMPs by 2020, even if the actions are not cost-effective from a water supply perspective. Water conservation offers multipurpose benefits such as reduced urban water treatment costs and potential reduction of fish entrainment at diversion structures. The Bulletin also identifies as likely additional demand reduction measures that would create new water and would be cost-competitive with supply augmentation options. These optional demand reductions are almost as large as the average year water supply augmentation options planned by local agencies.

California water agencies have also made great strides in water recycling. As discussed earlier, the new water supply produced from recycling has almost doubled between 1990 and 1995. By 2020, recycling could potentially contribute almost 1.4 maf of total water to the State's supplies, which would exceed the goal expressed in Section 13577 of the Water Code that total recycling statewide be 1 maf by 2010. (The potential 2020 recycling of 1.4 maf would represent about 2 percent of the State's 2020 water supply.) Water recycling offers multipurpose benefits, such as reduction of treatment plant discharges to waterbodies. Cost is a limiting factor in implementing recycling projects. Bulletin 160-98 forecasts that projects implemented by local agencies by 2020 will increase the State's new water supply from recycling to about 0.8 maf.

Clearly, conservation and recycling alone are not sufficient to meet California's future needs. Bulletin 160-98 has included all of the conservation and recycling measures likely to be implemented by 2020. Adding supply augmentation options identified by California's water purveyors still leaves a shortfall in meeting forecasted future demands. Review of local agencies' likely supply augmentation options shows that relatively few larger-scale or regional programs are in active planning, especially among small and mid-size water agencies. This outcome reflects local agencies' concerns about perceived implementability constraints associated with larger-scale options, and their affordability.

In the interests of maintaining California's vibrant economy, it is important that the State take an active role in assisting water agencies in meeting their future needs. New storage facilities are an important part of the mix of options needed to meet California's future needs. Just as water conservation and recycling provide multiple benefits, storage facilities offer flood control, power generation, and recreation in addition to water supply benefits. The devastating January 1997 floods in the Central Valley emphasized the need for increased attention to flood control. It is important for small and mid-size water agencies who could not develop such facilities on their own to have access to participation in regional projects. The more diversified water agencies' sources of supply are, the better their odds of improved water supply reliability.

An appropriate State role would be for the Department to take the lead in performing feasibility studies of potential storage projects—not on behalf of the SWP, but on behalf of all potentially interested water agencies. State funding support is needed to identify likely projects, so that local agencies may determine how those projects might benefit their service areas. In concept, the Department could use State funding to complete project feasibility studies, permitting, and environmental documentation for likely new storage facilities, removing uncertainties that would prevent smaller water agencies from funding planning studies themselves. Agencies wishing to participate in projects shown to be feasible would repay their share of the State planning costs as a condition of participation in a project. Feasible projects would likely be constructed by a consortium of local agencies acting through a joint powers agreement or other contractual mechanism.

Meeting California's future needs will require cooperation among all levels of government—federal, State, and local. Likewise, all three of California's water-using sectors—agricultural, environmental, and urban—must work together to recognize each others' legitimate needs and to seek solutions to meeting the State's future water shortages. When the Bay-Delta Accord was signed in 1994, it was hailed as a truce in, if not an end to, one of the State's longstanding water wars. The Accord, and the efforts by California agencies to negotiate a resolution to interstate and intrastate Colorado River water issues, represent a new spirit of fostering cooperation and consensus rather than competition and conflict. Such an approach will be increasingly necessary, given the magnitude of the water shortages facing California. Mutual accommodation of each others' needs is especially important in drought years, when water purveyors face the greatest water supply challenges. With continued efforts to prepare for the future, California can have safe and reliable water supplies for urban areas, adequate long-term water supplies to maintain the State's agricultural economy, and restoration and protection of fish and wildlife habitat.

5A

Regional Water Budgets with Existing Facilities and Programs

The following tables show the water budgets for each of the State's ten hydrologic regions with existing facilities and programs. Water use/supply totals and shortages may not sum due to rounding.

TABLE ES5A-1

North Coast Region Water Budget with Existing Facilities and Programs (taf)

	1995		2020	
	Average	*Drought*	*Average*	*Drought*
Water Use				
Urban	169	177	201	212
Agricultural	894	973	927	1,011
Environmental	19,544	9,518	19,545	9,518
Total	**20,607**	**10,668**	**20,672**	**10,740**
Supplies				
Surface Water	20,331	10,183	20,371	10,212
Groundwater	263	294	288	321
Recycled and Desalted	13	14	13	14
Total	**20,607**	**10,491**	**20,672**	**10,546**
Shortage	**0**	**177**	**0**	**194**

TABLE ES5A-2

San Francisco Bay Region Water Budget with Existing Facilities and Programs (taf)

	1995		2020	
	Average	*Drought*	*Average*	*Drought*
Water Use				
Urban	1,255	1,358	1,317	1,428
Agricultural	98	108	98	108
Environmental	5,762	4,294	5,762	4,294
Total	**7,115**	**5,760**	**7,176**	**5,830**
Supplies				
Surface Water	7,011	5,285	7,067	5,417
Groundwater	68	92	72	89
Recycled and Desalted	35	35	37	37
Total	**7,115**	**5,412**	**7,176**	**5,543**
Shortage	**0**	**349**	**0**	**287**

TABLE ES5A-3

Central Coast Region Water Budget with Existing Facilities and Programs (taf)

	1995		2020	
	Average	*Drought*	*Average*	*Drought*
Water Use				
Urban	286	294	379	391
Agricultural	1,192	1,279	1,127	1,223
Environmental	118	37	118	37
Total	**1,595**	**1,610**	**1,624**	**1,652**
Supplies				
Surface Water	318	160	368	180
Groundwater	1,045	1,142	1,041	1,159
Recycled and Desalted	18	26	42	42
Total	**1,381**	**1,328**	**1,452**	**1,381**
Shortage	**214**	**282**	**172**	**270**

TABLE ES5A-4

South Coast Region Water Budget with Existing Facilities and Programs (taf)

	1995		2020	
	Average	*Drought*	*Average*	*Drought*
Water Use				
Urban	4,340	4,382	5,519	5,612
Agricultural	784	820	462	484
Environmental	100	82	104	86
Total	**5,224**	**5,283**	**6,084**	**6,181**
Supplies				
Surface Water	3,839	3,196	3,625	3,130
Groundwater	1,177	1,371	1,243	1,462
Recycled and Desalted	207	207	273	273
Total	**5,224**	**4,775**	**5,141**	**4,865**
Shortage	**0**	**508**	**944**	**1,317**

TABLE ES5A-5

Sacramento River Region Water Budget with Existing Facilities and Programs (taf)

	1995		2020	
	Average	*Drought*	*Average*	*Drought*
Water Use				
Urban	766	830	1,139	1,236
Agricultural	8,065	9,054	7,939	8,822
Environmental	5,833	4,223	5,839	4,225
Total	**14,664**	**14,106**	**14,917**	**14,282**
Supplies				
Surface Water	11,881	10,022	12,196	10,012
Groundwater	2,672	3,218	2,636	3,281
Recycled and Desalted	0	0	0	0
Total	**14,553**	**13,239**	**14,832**	**13,293**
Shortage	**111**	**867**	**85**	**989**

TABLE ES5A-6

San Joaquin River Region Water Budget with Existing Facilities and Programs (taf)

	1995		2020	
	Average	*Drought*	*Average*	*Drought*
Water Use				
Urban	574	583	954	970
Agricultural	7,027	7,244	6,450	6,719
Environmental	3,396	1,904	3,411	1,919
Total	**10,996**	**9,731**	**10,815**	**9,609**
Supplies				
Surface Water	8,562	6,043	8,458	5,986
Groundwater	2,195	2,900	2,295	2,912
Recycled and Desalted	0	0	0	0
Total	**10,757**	**8,943**	**10,753**	**8,898**
Shortage	**239**	**788**	**63**	**711**

TABLE ES5A-7

Tulare Lake Region Water Budget with Existing Facilities and Programs (taf)

	1995		*2020*	
	Average	*Drought*	*Average*	*Drought*
Water Use				
Urban	690	690	1,099	1,099
Agricultural	10,736	10,026	10,123	9,532
Environmental	1,672	809	1,676	813
Total	**13,098**	**11,525**	**12,897**	**11,443**
Supplies				
Surface Water	7,888	3,693	7,791	3,593
Groundwater	4,340	5,970	4,386	5,999
Recycled and Desalted	0	0	0	0
Total	**12,228**	**9,663**	**12,177**	**9,592**
Shortage	**870**	**1,862**	**720**	**1,851**

TABLE ES5A-8

North Lahontan Region Water Budget with Existing Facilities and Programs (taf)

	1995		*2020*	
	Average	*Drought*	*Average*	*Drought*
Water Use				
Urban	39	40	50	51
Agricultural	530	584	536	594
Environmental	374	256	374	256
Total	**942**	**880**	**960**	**901**
Supplies				
Surface Water	777	557	759	557
Groundwater	157	187	183	208
Recycled and Desalted	8	8	8	8
Total	**942**	**752**	**950**	**773**
Shortage	**0**	**128**	**10**	**128**

TABLE ES5A-9

South Lahontan Region Water Budget with Existing Facilities and Programs (taf)

	1995		*2020*	
	Average	*Drought*	*Average*	*Drought*
Water Use				
Urban	238	238	619	619
Agricultural	332	332	257	257
Environmental	107	81	107	81
Total	**676**	**651**	**983**	**957**
Supplies				
Surface Water	322	259	437	326
Groundwater	239	273	248	296
Recycled and Desalted	27	27	27	27
Total	**587**	**559**	**712**	**649**
Shortage	**89**	**92**	**270**	**308**

TABLE ES5A-10

Colorado River Region Water Budget with Existing Facilities and Programs (taf)

	1995		2020	
	Average	*Drought*	*Average*	*Drought*
Water Use				
Urban	418	418	740	740
Agricultural	4,118	4,118	3,583	3,583
Environmental	39	38	44	43
Total	**4,575**	**4,574**	**4,367**	**4,366**
Supplies				
Surface Water	4,154	4,128	3,920	3,909
Groundwater	337	337	285	284
Recycled and Desalted	15	15	15	15
Total	**4,506**	**4,479**	**4,221**	**4,208**
Shortage	**69**	**95**	**147**	**158**

5B

Regional Water Budgets with Options Likely to be Implemented

The following tables show the water budgets for each of the State's ten hydrologic regions with options likely to be implemented. Water use/supply totals and shortages may not sum due to rounding.

TABLE ES5B-1

North Coast Region Water Budget with Options (taf)

	1995		2020	
	Average	*Drought*	*Average*	*Drought*
Water Use				
Urban	169	177	201	194
Agricultural	894	973	927	1,011
Environmental	19,544	9,518	19,545	9,518
Total	**20,607**	**10,668**	**20,672**	**10,722**
Supplies				
Surface Water	20,331	10,183	20,371	10,212
Groundwater	263	294	288	321
Recycled and Desalted	13	14	13	14
Total	**20,607**	**10,491**	**20,672**	**10,546**
Shortage	**0**	**177**	**0**	**176**

TABLE ES5B-2

San Francisco Bay Region Water Budget with Options (taf)

	1995		2020	
	Average	*Drought*	*Average*	*Drought*
Water Use				
Urban	1,255	1,358	1,317	1,371
Agricultural	98	108	98	108
Environmental	5,762	4,294	5,762	4,294
Total	**7,115**	**5,760**	**7,176**	**5,773**
Supplies				
Surface Water	7,011	5,285	7,067	5,607
Groundwater	68	92	72	96
Recycled and Desalted	35	35	37	70
Total	**7,115**	**5,412**	**7,176**	**5,773**
Shortage	**0**	**349**	**0**	**0**

TABLE ES5B-3

Central Coast Region Water Budget with Options (taf)

	1995		2020	
	Average	*Drought*	*Average*	*Drought*
Water Use				
Urban	286	294	347	359
Agricultural	1,192	1,279	1,127	1,223
Environmental	118	37	118	37
Total	**1,595**	**1,610**	**1,592**	**1,620**
Supplies				
Surface Water	318	160	477	287
Groundwater	1,045	1,142	1,043	1,161
Recycled and Desalted	18	26	71	71
Total	**1,381**	**1,328**	**1,592**	**1,519**
Shortage	**214**	**282**	**0**	**100**

TABLE ES5B-4

South Coast Region Water Budget with Options (taf)

	1995		2020	
	Average	*Drought*	*Average*	*Drought*
Water Use				
Urban	4,340	4,382	5,435	5,528
Agricultural	784	820	455	477
Environmental	100	82	104	86
Total	**5,224**	**5,283**	**5,993**	**6,090**
Supplies				
Surface Water	3,839	3,196	4,084	3,832
Groundwater	1,177	1,371	1,243	1,592
Recycled and Desalted	207	207	667	667
Total	**5,224**	**4,775**	**5,994**	**6,090**
Shortage	**0**	**508**	**0**	**0**

TABLE ES5B-5

Sacramento River Region Water Budget with Options (taf)

	1995		2020	
	Average	*Drought*	*Average*	*Drought*
Water Use				
Urban	766	830	1,139	1,236
Agricultural	8,065	9,054	7,939	8,822
Environmental	5,833	4,223	5,839	4,225
Total	**14,664**	**14,106**	**14,917**	**14,282**
Supplies				
Surface Water	11,881	10,022	12,282	10,279
Groundwater	2,672	3,218	2,636	3,281
Recycled and Desalted	0	0	0	0
Total	**14,553**	**13,239**	**14,918**	**13,560**
Shortage	**111**	**867**	**0**	**722**

TABLE ES5B-6

San Joaquin River Region Water Budget with Options (taf)

	1995		2020	
	Average	*Drought*	*Average*	*Drought*
Water Use				
Urban	574	583	954	970
Agricultural	7,027	7,244	6,448	6,717
Environmental	3,396	1,904	3,411	1,919
Total	**10,996**	**9,731**	**10,813**	**9,607**
Supplies				
Surface Water	8,562	6,043	8,497	6,029
Groundwater	2,195	2,900	2,317	2,920
Recycled and Desalted	0	0	0	0
Total	**10,757**	**8,943**	**10,814**	**8,949**
Shortage	**239**	**788**	**0**	**658**

TABLE ES5B-7

Tulare Lake Region Water Budget with Options (taf)

	1995		*2020*	
	Average	*Drought*	*Average*	*Drought*
Water Use				
Urban	690	690	1,099	1,099
Agricultural	10,736	10,026	10,106	9,515
Environmental	1,672	809	1,676	813
Total	**13,098**	**11,525**	**12,880**	**11,426**
Supplies				
Surface Water	7,888	3,693	8,292	4,167
Groundwater	4,340	5,970	4,386	6,391
Recycled and Desalted	0	0	0	0
Total	**12,228**	**9,663**	**12,678**	**10,558**
Shortage	**870**	**1,862**	**202**	**868**

TABLE ES5B-8

North Lahontan Region Water Budget with Options (taf)

	1995		*2020*	
	Average	*Drought*	*Average*	*Drought*
Water Use				
Urban	39	40	50	51
Agricultural	530	584	536	594
Environmental	374	256	374	256
Total	**942**	**880**	**960**	**901**
Supplies				
Surface Water	777	557	759	557
Groundwater	157	187	183	208
Recycled and Desalted	8	8	8	8
Total	**942**	**752**	**950**	**773**
Shortage	**0**	**128**	**10**	**128**

TABLE ES5B-9

South Lahontan Region Water Budget with Options (taf)

	1995		*2020*	
	Average	*Drought*	*Average*	*Drought*
Water Use				
Urban	238	238	568	568
Agricultural	332	332	252	252
Environmental	107	81	107	81
Total	**676**	**651**	**927**	**901**
Supplies				
Surface Water	322	259	651	578
Groundwater	239	273	248	296
Recycled and Desalted	27	27	27	27
Total	**587**	**559**	**926**	**901**
Shortage	**89**	**92**	**0**	**0**

TABLE ES5B-10

Colorado River Region Water Budget with Options (taf)

	1995		*2020*	
	Average	*Drought*	*Average*	*Drought*
Water Use				
Urban	418	418	715	715
Agricultural	4,118	4,118	3,393	3,393
Environmental	39	38	44	43
Total	**4,575**	**4,574**	**4,152**	**4,151**
Supplies				
Surface Water	4,154	4,128	3,852	3,852
Groundwater	337	337	285	284
Recycled and Desalted	15	15	15	15
Total	**4,506**	**4,479**	**4,152**	**4,151**
Shortage	**69**	**95**	**0**	**0**

Abbreviations and Acronyms

A

AB	Assembly Bill
AAC	All American Canal
ACID	Anderson-Cottonwood Irrigation District
ACWD	Alameda County Water District
AD	allowable depletion
ADWR	Arizona Department of Water Resources
AEWSD	Arvin-Edison Water Storage District
af	acre-foot/acre-feet
AFB	Air Force Base
AFRP	Anadromous fish restoration program (or plan)
AMD	acid mine drainage
AOP	advanced oxidation process
APCD	air pollution control district
ARP	aquifer reclamation program
ARWI	American River Watershed Investigation
ARWRI	American River Water Resources Investigation
ASR	aquifer storage and recovery
AVEK	Antelope Valley-East Kern Water Agency
AVWG	Antelope Valley Water Group

B

BARWRP	Bay Area regional water recycling program
BAT	best available technology
BBID	Byron-Bethany Irrigation District
BDAC	Bay-Delta Advisory Council
B/C	benefit-to-cost (ratio)
BLM	Bureau of Land Management
BMP	Best management practice
BVWSD	Buena Vista Water Storage District
BWD	Bard Water District
BWRDF	Brackish water reclamation demonstration facility

C

CAL-AM	California-American Water Company
Cal/EPA	California Environmental Protection Agency
CALFED	State (CAL) and federal (FED) agencies participating in Bay-Delta Accord
CAP	Central Arizona Project
CAWCD	Central Arizona Water Conservation District
CCID	Central California Irrigation District
CCMP	Comprehensive conservation and management plan
CCWD	Colusa County Water District or Contra Costa Water District
CDI	capacitive deionization
CEQA	California Environmental Quality Act
CESA	California Endangered Species Act
cfs	cubic feet per second
CII	commercial, industrial, and institutional
CIMIS	California irrigation management information system
CLWA	Castaic Lake Water Agency
CMWD	Calleguas Municipal Water District
COA	Coordinated Operation Agreement
COG	Council of Governments
CMO	crop market outlook
COP	certificate of participation
CPUC	California Public Utilities Commission
CRA	Colorado River Aqueduct
CRB	Colorado River Board
CRIT	Colorado River Indian Tribes
CSD	community services district
CSIP/SVRP	Castroville Seawater Intrusion Project/ Salinas Valley Reclamation Project
CSJWCD	Central San Joaquin Water Conservation District
CUWCC	California Urban Water Conservation Council

CVHJV	Central Valley Habitat Joint Venture
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
CVPM	Central Valley production model
CVWD	Coachella Valley Water District
CWA	Clean Water Act
CWD	Coastal Water District, Cawelo Water District, or county water district

D

D-1485	State Water Resources Control Board Water Right Decision 1485
DAU	detailed analysis unit
DBCP	dibromochloropropane
DBP	disinfection by-products
DCID	Deer Creek Irrigation District
D/DBP	disinfectant/disinfection by-product
DDT	dichloro diphenyl trichloroethane
DEIR	draft environmental impact report
DEIS	draft environmental impact statement
DFA	California Department of Food and Agriculture
DFG	California Department of Fish and Game
DHS	California Department of Health Services
DMC	Delta-Mendota Canal
DOE	Department of Energy
DOF	California Department of Finance
DOI	Department of the Interior
DPR	Department of Parks and Recreation or Department of Pesticide Regulation
DU	distribution uniformity
DWA	Desert Water Agency
DWB	DWR's Drought Water Bank
DWD	Diablo Water District
DWR	California Department of Water Resources
DWRSIM	DWR's operations model for SWP/CVP system

E

EBMUD	East Bay Municipal Utility District
ec	electrical conductivity
ECCID	East Contra Costa Irrigation District
ECWMA	East County Water Management Association
ED	electrodialysis
EDB	ethylene dibromide
EDCWA	El Dorado County Water Agency
EDF	Environmental Defense Fund
EDR	electrodialysis reversal
EID	El Dorado Irrigation District
EIR	environmental impact report
EIS	environmental impact statement
ENSO	El Niño Southern Oscillation cycle
EPA	U.S. Environmental Protection Agency or Energy Policy Act of 1992
ERP	ecosystem restoration program or plan
ESA	Endangered Species Act
ESP	emergency storage project
ESU	evolutionarily significant unit
ESWTR	Enhanced Surface Water Treatment Rule
ET	evapotranspiration
ET_o	reference evapotranspiration
ETAW	evapotranspiration of applied water
EWMP	efficient water management practice

F

FAIRA	Federal Agriculture Improvement and Reform Act
FC&WCD	flood control and water conservation district
FCD	flood control district
FERC	Federal Energy Regulatory Commission
FY	fiscal year

G

GAC	granular activated carbon
GBUAPCD	Great Basin Unified Air Pollution Control District
GCID	Glenn-Colusa Irrigation District
GDPUD	Georgetown Divide Public Utility District
GO	general obligation
gpcd	gallons per capita per day
gpf	gallons per flush
gpm	gallons per minute

H

HCP	habitat conservation plan
HLWA	Honey Lake Wildlife Area
HR	House Resolution
HUD	Department of Housing and Urban Development

I

IBWC	International Boundary and Water Commission
ICR	information collection rule
ID	irrigation district or improvement district
IE	irrigation efficiency
IEP	Interagency Ecological Program
IID	Imperial Irrigation District
IOT	intake opportunity time
IRP	integrated resources planning
IRWD	Irvine Ranch Water District
ISDP	Interim South Delta Program

J

JPA	joint powers authority

K

KCWA	Kern County Water Agency
KPOP	Klamath Project Operations Plan
KRCC	Klamath River Compact Commission
KWB	Kern Water Bank
KWBA	Kern Water Bank Authority
kWh	kilowatt hour

L

LAA	Los Angeles Aqueduct
LADWP	Los Angeles Department of Water and Power
LAFCO	local agency formation commission
LBG	Los Banos Grandes
LCRMSCP	Lower Colorado River Multi-Species Conservation Program
LEPA	low-energy precision application
LMMWC	Los Molinos Mutual Water Company
LTBMU	Lake Tahoe Basin Management Unit

M

m	meter
maf	million acre-feet
MCL	maximum contaminant level
MCWD	Marina Coast Water District or Mammoth Community Water District
MCWRA	Monterey County Water Resources Agency
MF	microfiltration or Middle Fork
mgd	million gallons per day
mg/L	milligrams per liter
M&I	municipal & industrial
MID	Madera Irrigation District, Maxwell Irrigation District, Merced Irrigation District, or Modesto Irrigation District
MMWC	McFarland Mutual Water Company
MMWD	Marin Municipal Water District
MOU	memorandum of understanding
MPWMD	Monterey Peninsula Water Management District
MRWPCA	Monterey Regional Water Pollution Control Agency
MTBE	methyl tertiary butyl ether
MUD	municipal utility district
mW	megawatt
MWA	Mojave Water Agency
MWD	municipal water district
MWDOC	Municipal Water District of Orange County
MWDSC	Metropolitan Water District of Southern California

N

NAWMP	North American Waterfowl Management Plan
NCFC&WCD	Napa County Flood Control and Water Conservation District
NCMWC	Natomas-Central Mutual Water Company
NED	national economic development (plan)
NEPA	National Environmental Policy Act
NF	nanofiltration or North Fork
NGO	non-governmental organization
NID	Nevada Irrigation District
NISA	National Invasive Species Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOP	notice of preparation
NPDES	national pollutant discharge elimination system
NPDWR	national primary drinking water regulations
NRCS	Natural Resources Conservation Service
NTU	Nephelometric Turbidity Unit
NWD	Northridge Water District
NWR	National Wildlife Refuge

O

OCWD	Orange County Water District
OID	Oakdale Irrigation District
O&M	operations and maintenance

P

PAC	powdered activated carbon
PAH	polynuclear aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCE	perchloroethylene
PCGID/PID	Princeton-Codora-Glenn Irrigation District/Provident Irrigation District
PCWA	Placer County Water Agency
PEIR	programmatic environmental impact report
PEIS	programmatic environmental impact statement
PG&E	Pacific Gas and Electric Company
PGVMWC	Pleasant Grove-Verona Mutual Water Company
PL	Public Law
PMWC	Pelger Mutual Water Company
ppb	parts per billion
PROSIM	USBR's operations model for the CVP/SWP
PSA	planning subarea
psi	pounds per square inch
PTA	packed-tower aeration
PUC	public utility commission
PUD	public utility district
PVID	Palo Verde Irrigation District or Pleasant Valley Irrigation District
PVWMA	Pajaro Valley Water Management Agency
PWD	Palmdale Water District

R

RBDD	Red Bluff Diversion Dam
RCD	resource conservation district
RD	reclamation district
RDI	regulated deficit irrigation
RO	reverse osmosis
RWQCB	Regional Water Quality Control Board

S

SAE	seasonal application efficiency
SAFCA	Sacramento Area Flood Control Agency
SAWPA	Santa Ana Watershed Project Authority
SB	Senate Bill
SBCFC&WCD	Santa Barbara County Flood Control and Water Conservation District
SBVMWD	San Bernardino Valley Municipal Water District
SCCWRRS	Southern California comprehensive water reclamation and reuse study
SCE	Southern California Edison
SCVWD	Santa Clara Valley Water District
SCWA	Solano County Water Agency or Sonoma County Water Agency
SDCWA	San Diego County Water Authority
SDWA	Safe Drinking Water Act or South Delta Water Agency
SEIS	supplemental environmental impact statement
SEWD	Stockton East Water District
SF	South Fork
SFBJV	San Francisco Bay Joint Venture
SFEP	San Francisco Estuary Project
SFPUC	San Francisco Public Utility Commission
SFWD	San Francisco Water Department
SGPWA	San Gorgonio Pass Water Agency
SID	Solano Irrigation District
SJBAP	San Joaquin Basin Action Plan
SJRMP	San Joaquin River Management Plan (or Program)
SLC	San Luis Canal
SLD	San Luis Drain
SLDMWA	San Luis & Delta-Mendota Water Authority
SLOCFC&WCD	San Luis Obispo County Flood Control and Water Conservation District
SMBRP	Santa Monica Bay restoration project
SMUD	Sacramento Municipal Utility District
SNWA	Southern Nevada Water Authority
SOC	synthetic organic compound
SOFAR	South Fork American River (project)
SPPC	Sierra Pacific Power Company
SRCD	Suisun Resource Conservation District
SRF	state revolving fund
SRFCP	Sacramento River Flood Control Project
SRI	Sacramento River index
SSA	Salton Sea Authority
SSJID	South San Joaquin Irrigation District
SSWD	South Sutter Water District

STPUD	South Tahoe Public Utility District
SVGMD	Sierra Valley Groundwater Management District
SVOC	semi-volatile organic compound
SVRID	Stanford Vina Ranch Irrigation District
SVRP	Salinas Valley reclamation project
SWP	State Water Project
SWPP	source water protection program or supplemental water purchase program
SWRCB	State Water Resources Control Board
SWSD	Semitropic Water Storage District

T

taf	thousand acre-feet
TCC	Tehama-Colusa Canal
TCD	temperature control device
TCE	trichloroethylene
TDPUD	Tahoe Donner Public Utility District
TDS	total dissolved solids
THM	trihalomethane
TID	Turlock Irrigation District
TID-MID	Turlock Irrigation District and Modesto Irrigation District
TOC	total organic carbon
TROA	Truckee River Operating Agreement
TRPA	Tahoe Regional Planning Agency

U

UC	University of California
UCD	University of California at Davis
UF	ultrafiltration
ULFT	ultra low flush toilet
USBR	U.S. Bureau of Reclamation
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UV	ultraviolet
UWCD	United Water Conservation District

V

VAMP	Vernalis adaptive management plan
VOC	volatile organic compound

W

WA	water agency, water authority, or wildlife area
WCD	water conservation district
WCWD	Western Canal Water District
WD	water district
WMD	water management district
WMI	watershed management initiative
WQA	water quality authority
WQCP	water quality control plan
WR 95-6	SWRCB Order WR 95-6
WRCD	Westside Resource Conservation District
WRDA	Water Resources Development Act
WRF	water reclamation facility or water recycling facility
WRID	Walker River Irrigation District
WSD	water storage district
WTP	water treatment plant
WWD	Westlands Water District
WWTP	wastewater treatment plant

Y

YCFC&WCD	Yolo County Flood Control and Water Conservation District
YCWA	Yuba County Water Agency

Z

Z7WA	Zone 7 Water Agency

NOTES

NOTES

Conversion Factors

Quantity	To convert from customary unit	To metric unit	Multiply customary unit by	To convert to customary unit, multiply metric unit by
Length	inches (in)	millimeters (mm)●	25.4	0.03937
	inches (in)	centimeters (cm)	2.54	0.3937
	feet (ft)	meters (m)	0.3048	3.2808
	miles (mi)	kilometers (km)	1.6093	0.62139
Area	square inches (in^2)	square millimeters (mm^2)	645.16	0.00155
	square feet (ft^2)	square meters (m^2)	0.092903	10.764
	acres (ac)	hectares (ha)	0.40469	2.4710
	square miles (mi^2)	square kilometers (km^2)	2.590	0.3861
Volume	gallons (gal)	liters (L)	3.7854	0.26417
	million gallons (10^6 gal)	megaliters (ML)	3.7854	0.26417
	cubic feet (ft^3)	cubic meters (m^3)	0.028317	35.315
	cubic yards (yd^3)	cubic meters (m^3)	0.76455	1.308
	acre-feet (ac-ft)	thousand cubic meters ($m^3 \times 10^3$)	1.2335	0.8107
	acre-feet (ac-ft)	hectare-meters (ha - m)■	0.1234	8.107
	thousand acre-feet (taf)	million cubic meters ($m^3 \times 10^6$)	1.2335	0.8107
	thousand acre-feet (taf)	hectare-meters (ha - m)■	123.35	0.008107
	million acre-feet (maf)	billion cubic meters ($m^3 \times 10^9$)◆	1.2335	0.8107
	million acre-feet (maf)	cubic kilometers (km^3)	1.2335	0.8107
Flow	cubic feet per second (ft^3/s)	cubic meters per second (m^3/s)	0.028317	35.315
	gallons per minute (gal/min)	liters per minute (L/min)	3.7854	0.26417
	gallons per day (gal/day)	liters per day (L/day)	3.7854	0.26417
	million gallons per day (mgd)	megaliters per day (ML/day)	3.7854	0.26417
	acre-feet per day (ac-ft/day)	thousand cubic meters per day ($m^3 \times 10^3$/day)	1.2335	0.8107
Mass	pounds (lb)	kilograms (kg)	0.45359	2.2046
	tons (short, 2,000 lb)	megagrams (Mg)	0.90718	1.1023
Velocity	feet per second (ft/s)	meters per second (m/s)	0.3048	3.2808
Power	horsepower (hp)	kilowatts (kW)	0.746	1.3405
Pressure	pounds per square inch (psi)	kilopascals (kPa)	6.8948	0.14505
	head of water in feet	kilopascals (kPa)	2.989	0.33456
Specific capacity	gallons per minute per foot of drawdown	liters per minute per meter of drawdown	12.419	0.08052
Concentration	parts per million (ppm)	milligrams per liter (mg/L)	1.0	1.0
Electrical conductivity	micromhos per centimeter	microsiemens per centimeter (mS/cm)	1.0	1.0
Temperature	degrees Fahrenheit (°F)	degrees Celsius (°C)	(°F - 32)/1.8	(1.8 x °C) + 32

● When using "dual units," inches are normally converted to millimeters (rather than centimeters).

■ Not used often in metric countries, but is offered as a conceptual equivalent of customary western U.S. practice (a standard depth of water over a given area of land).

◆ ASTM Manual E380 discourages the use of billion cubic meters since that magnitude is represented by giga (a thousand million) in other countries. It is shown here for potential use for quantifying large reservoir volumes (similar to million acre-feet).

Other Common Conversion Factors

1 cubic foot=7.48 gallons=62.4 pounds of water

1 cubic foot per second (cfs)=450 gallons per minute (gpm)

1 cfs=646,320 gallons a day=1.98 ac-ft a day

1 acre-foot=325,900 gallons=43,560 cubic feet

1 million gallons=3.07 acre-feet

1 million gallons a day (mgd)=1,120 ac-ft a year

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