CENTER FOR FOOD SAFETY

October 17, 2016

VIA ELECTRONIC MAIL

California Department of Water Resources
Attn: Ted Alvarez
State Water Project Analysis Officer
SWP Support Branch
1416 9th Street, Room 1620
Sacramento, CA 95814
ted.alvarez@water.ca.gov

Comments on the Department of Water Resources Draft Environmental Impact Report for the Water Supply Contract Extension Project

To Department of Water Resources ("DWR"):

The Center for Food Safety ("CFS") appreciates the opportunity to comment on the Draft Environmental Impact Report ("DEIR") for the Water Supply Contract Extension Project ("Project"). CFS and its members depend on the sustainable and equitable operation of the State Water Project ("SWP") and take great interest in the Project for the opportunity—and obligation—that the Project presents to mitigate the SWP's environmental impacts. These comments are submitted on behalf of CFS, as well as its members, volunteers, and employees.

CFS is a nonprofit, public interest advocacy organization dedicated to protecting human health and the environment by curbing the proliferation of harmful food production technologies and promoting sustainable agriculture, including impacts to water resources. In furtherance of this mission, CFS uses legal actions, groundbreaking scientific and policy reports, books and other educational materials, and grassroots campaigns on behalf of its 750,000 farmer and consumer members across the country.

I. INTRODUCTION

The Project seeks to finance capital expenditures to the SWP beyond the 2035 expiration date set in the current contracts by signing long-term extensions for each contract. (DEIR at ES-1.) The SWP is the largest state-owned, multi-purpose, user-financed water storage and delivery system in the United States. (*Id.* at 2-2.) DWR constructed and currently operates and

NATIONAL HEADQUARTERS
660 Pennsylvania Avenue, SE, Suite 302
Washington, D.C. 20003
T: 202-547-9359 F: 202-547-9429

CALIFORNIA OFFICE
303 Sacramento Street, 2nd Floor
San Francisco, CA 94111
T: 415-826-2770 F: 415-826-0507

PACIFIC NORTHWEST OFFICE
917 SW Oak Street, Suite 300
Portland, OR 97205
T: 971-271-7372 F: 971-271-7374

HAWAI'I OFFICE
1132 Bishop Street, Suite 2107
Honolulu, Hawaii 96813
T: 808-681-7688

office@centerforfoodsafety.org centerforfoodsafety.org

maintains the SWP, which conveys water to twenty-nine water contractors. (*Id*. at ES-1.) The contractors receive water service from the SWP in exchange for paying the costs that are associated with constructing, operating, and maintaining the SWP facilities. (*Ibid*.) DWR finances capital expenditures on the SWP by selling revenue bonds with terms of up to thirty years or more. However, according to DWR, it has become more challenging to finance expenditures because it is getting difficult to sell long-term revenue bonds beyond 2035, the date the contracts begin to expire. (*Ibid*.) Thus, the Project seeks to amend the financial sections of the contracts to ensure that DWR can finance SWP expenditures beyond 2035. (*Id*. at ES-3.)

Notwithstanding the importance of conveying water to a large portion of California's population, the SWP has contributed to a substantial decline in the Sacramento-San Joaquin Delta watershed ("Bay-Delta") ecosystem for the past fifty years. Water delivery is estimated in each of the contracts and included in a schedule for each contractor that sets forth the maximum annual amount of water that may be requested, which is known as the annual Table A amounts. (*Id*. at 2-12.) The contracts require DWR to make all reasonable efforts to deliver the full Table A amounts; however, the Table A amounts are much higher than those the SWP is capable of providing. This is one of the leading causes of the precipitous decline in the health of the Bay-Delta.

Realizing the crisis facing the Bay-Delta, the California State Legislature passed the Sacramento-San Joaquin Delta Reform Act of 2009 ("Delta Reform Act") to ensure that all projects involving the Bay-Delta will meet the coequal goals of providing a more reliable water supply for California and protecting, restoring, and enhancing the Bay-Delta ecosystem. Despite the fact that the SWP unequivocally is subject to these requirements, the Project fails to align the contract extensions with the Delta Reform Act.

The DEIR is also deficient in its description of the future expenditures that will be enabled by the Project, failing to mention a single expenditure for which the money will be used. Most significantly, the DEIR fails to include an analysis of California WaterFix, which is an enormous expenditure that will likely be funded, at least in part, by the funds generated as a result of the Project. Without an analysis of proposed future expenditures to the SWP—and in particular California WaterFix—it is impossible to evaluate the environmental impacts of the Project, and the DEIR fails in its role as an informational document.

II. THE CALIFORNIA ENVIRONMENTAL QUALITY ACT ("CEQA")

Under CEQA, a public agency must prepare an environmental impact report ("EIR") on any project the agency proposes to "carry out or approve" if the project may have significant environmental effects. (*Save Tara v. City of Hollywood* (2008) 45 Cal.4th 116, 121 [citing Pub. Resources Code, §§ 21100, subd. (a), 21151, subd. (a)].) An EIR is a "detailed statement … describing and analyzing the significant effects of a project and discussing ways to mitigate or avoid the effects." (Cal. Code Regs., tit. 14, § 15362 ("CEQA Guidelines").) The EIR is intended "to demonstrate to an apprehensive citizenry that the agency has, in fact, analyzed and considered the ecological implications of its action. (*County of Amador v. El Dorado Water Agency* (1999) 76 Cal.App.4th 931, 944.) Because the EIR must be certified or rejected by public officials, it is a document of accountability. (*Ibid*.)

A crucial component of the EIR "is to ensure that all reasonable alternatives to Projects are thoroughly assessed by the responsible official." (*Laurel Heights Improvement Assn. v. Regents of University of California* (1988) 47 Cal.3d 376, 400 [citing *Wildlife v. Chickering* (1976) 18 Cal.3d 190, 197].) An EIR must describe a reasonable range of alternatives to the project, or to the location of the project, that could feasibly attain most of the basic objectives of the project while avoiding or substantially lessening any of the significant effects of the project. (CEQA Guidelines, § 15126.6, subds. (a), (f).)

Another chief purpose of an EIR is the cumulative impact analysis. (*San Franciscans for Reasonable Growth v. City and County of San Francisco* (1984) 151 Cal.App.3d 61, 72-73.) The cumulative impacts from several projects is the change in the environment which results from the incremental impact of the project when added to other closely related past, present, and reasonably foreseeable probable future projects. (*Id*. at 73 [citing CEQA Guidelines, § 15355, subd. (b) (formerly § 15023.5, subd. (b).)].) Lead agencies therefore must prepare a list of projects producing related or cumulative impacts. (*Ibid*.)

III. THE SACRAMENTO-SAN JOAQUIN DELTA REFORM ACT OF 2009 ("DELTA REFORM ACT")

In 2009, the California State Legislature determined that the Bay-Delta and California's water infrastructure were "in crisis and the existing Delta policies were not sustainable." (California Water Code, § 85001, subd. (a).) Accordingly, the State found that resolving the crisis required fundamental reorganization of the State's management of Bay-Delta watershed resources. (*Ibid*.) In an effort to resolve the crisis, a new policy was enacted to guide management decisions of the Bay-Delta, known as the Delta Policy.

Under the Delta Policy, the California Legislature declared that the basic goals for the Bay-Delta are the following:

(a) Achieve the two coequal goals of providing a more reliable water supply for California and protecting, restoring, and enhancing the Bay-Delta ecosystem. The coequal goals shall be achieved in a manner that protects and enhances the unique cultural, recreational, natural resource, and agricultural values of the Bay-Delta as an evolving place;

(b) Protect, maintain, and, where possible, enhance and restore the overall quality of the Bay-Delta environment, including, but not limited to, agriculture, wildlife habitat, and recreational activities;

(c) Ensure orderly, balanced conservation and development of Bay-Delta land resources; and

(d) Improve flood protection by structural and nonstructural means to ensure an increased level of public health and safety.

(Pub. Resources Code, § 29702.) The California Water Code further elaborates that the State of California must reduce reliance on the Bay-Delta in meeting California's future water supply needs through a statewide strategy of investing in improved regional supplies, conservation, and water use efficiency. (California Water Code, § 85021.)

Under the Delta Reform Act, a state or local public agency that proposes to undertake a covered action shall prepare a written certification of consistency with detailed findings as to whether the covered action is consistent with the Delta Policy and shall submit that certification to the Delta Stewardship Council. (California Water Code, § 85225.) An action is covered if it is a plan, program, or project that occurs within the boundaries of the Bay-Delta, funded by a state or local public agency, is covered by at least one provision of the Delta Plan, and will have a significant impact on the coequal goals of the Delta Policy. (California Water Code, § 85057.5, subd. (a).) Regarding the SWP, an action is not covered only if it involves routine maintenance. (*Id*., subd. (b)(2).)

Since a proposal to implement the Water Supply Contract Extension Project is likely a covered action, and is more than just routine maintenance, DWR must draft a written certification of consistency with detailed findings indicating that it is consistent with the Delta Plan and will meet the coequal goals of the Delta Policy.

a. DWR Must Align the SWP Long-Term Contracts with the Delta Policy.

In proposing to implement the Water Supply Contract Extension Project, DWR has an opportunity and requirement to ensure that the SWP long-term contracts meet the coequal policy requirements of the Delta Reform Act. That is, in extending the SWP long-term contracts, DWR must provide a more reliable water supply for California as well as protect, restore, and enhance the Bay-Delta ecosystem. By amending only the financial terms of the contracts, yet extending the terms of the contracts to 2085, DWR is failing to meet the coequal goals of the Delta Policy, and failing to meet its obligations under the Delta Reform Act.

The SWP was enacted into law in the Burns-Porter Act (California Water Code, § 12930 et seq.), which was passed by the California Legislature in 1959 and approved by the voters in 1960. (DEIR at 2-1.) The SWP delivers water pursuant to contracts between DWR and twenty-nine contractors, including water agencies, throughout California. (*Ibid*.) The Burns-Porter Act authorized the State of California to issue bonds for construction of the SWP and enter into contracts for the sale, delivery, or use of water or power made available by the SWP. (*Id*. at 2-1 to 2-2.) In return for state financing, public water agencies contractually agreed to repay all SWP capital and operating costs allocable to water supply. (*Id*. at 2-2.)

The SWP diverts large volumes of water from the Bay-Delta, which flows down the California Aqueduct and is eventually delivered to the contractors. (*Id*. at 2-16.) Each year, by the first of October, the contractors submit monthly water requests to DWR for the subsequent calendar year to receive the water diverted from the Bay-Delta. (*Ibid*.) The amounts requested are the Table A amounts, which set the maximum annual amount of water that may be requested to be delivered. (*Id*. at 2-12.) The contracts require DWR to make all reasonable efforts to complete the water supply facilities necessary to deliver the full Table A amounts in the contracts, but when the supply of Table A water is less than the total of all contractors' requests, the available supply of Table A water is allocated among all contractors in proportions to each contractors' annual Table A amount. (*Ibid*.) Thus, the current contracts focus on supplying the maximum amount of water for human consumption, including agriculture and industry, with little to no regards to the ecology of the region.

Due to the long-term contracts' focus on DWR supplying the maximum amount of water to the contractors, and the SWP's reliance on the Bay-Delta, the SWP has played a large role in devastating the Bay-Delta ecosystem. According to DWR's 2011 SWP Delivery Reliability Report, SWP pumping is "not sustainable over the long term under current management practices and regulatory requirements." (Cal. Dept. of Water Resources, Final Delivery Reliability Report (2011) ("2011 DRR") p. 32 (Attached as Exhibit A).) That is partially why, in 2009, the California Legislature determined that the Bay-Delta was in crisis and passed the Delta Reform Act to restore the ecosystem and reduce the State's reliance on the Bay-Delta as a water supply. Thus, in extending the contracts that supply Bay-Delta water through the SWP for an additional fifty years, DWR cannot and should not maintain the same wasteful practices that led to the deterioration of the Bay-Delta's ecosystem in the first place.

b. Alternatives that Align the SWP Long-Term Contracts with the Delta Policy.

There are multiple ways DWR can align the Project with the Delta Policy, which DWR included but rejected in its alternatives analysis. As mentioned above, one of an EIR's major functions "is to ensure that all reasonable alternatives to proposed projects are thoroughly assessed by the responsible agency." (*Laurel Heights Improvement Assn. v. Regents of University of California*, *supra*, 47 Cal.3d at p. 400.) Public agencies "should not approve projects as proposed if there are feasible alternatives or feasible mitigation measures available which would substantially lessen the significant environmental effects of such projects." (*Id*. [citing Pub. Resources Code, § 21002].) When an alternative is found to be infeasible on the ground that it is inconsistent with the project objectives, the finding must be supported by substantial evidence in the record. (*California Native Plant Soc. v. City of Santa Cruz* (2009) 177 Cal.App.4th 957, 604.)

DWR need only evaluate alternatives that meet the project objectives. DWR and the contractors agreed to the following project objectives:

(1) Ensure DWR can finance SWP expenditures beyond 2035 for a sufficiently extended period to provide for a reliable stream of revenue from the contractors and to facilitate ongoing financial planning for the SWP;

(2) Maintain an appropriate level of reserves and funds to meet ongoing financial SWP needs and purposes;

(3) Simplify the SWP billing process; and

(4) Increase coordination of financial matters between DWR and the contractors.

(DEIR at ES-3.) The alternatives that DWR considered meet the project objectives, but DWR erroneously rejected them.

i. Reduce Table A Deliveries.

During the scoping process, comments recommended that the DEIR should include an alternative with a reduction of the maximum Table A deliveries to contractors based on DWR reliability reports, climate change reports, and the Delta Reform Act, as well as associated reports on future water supplies. (DEIR at 7-3.) As the DEIR mentions, annual Table A amounts set forth the maximum annual amount of water that may be requested by contractors, and under the terms of the contracts DWR must make all reasonable efforts to perfect and protect those water rights. (*Ibid*.) A history of Table A deliveries indicates that DWR frequently attempts to give the maximum amount of Table A deliveries, which is not sustainable and degrades the Bay-Delta ecosystem. (DEIR at 2-14.) Thus, if Table A amounts were to be reduced to amounts that aligned with the amount of water the SWP can reliably and sustainably deliver each year, DWR would not be pressured to pump more water than the Bay-Delta is capable of providing.

In fact, there is no justification for including the original full Table A amounts in the new contracts. DWR cannot deliver these allocations because they simply do not exist. According to the 2011 DRR, there is a zero percent chance of delivering more than 3,365 acre feet in a given year, even though the maximum Table A amount is 4,133 acre feet. (2011 DRR at 46-49.) The Bay-Delta faces numerous challenges to its long-term sustainability, including continued subsidence of Bay-Delta Islands, many of which are below sea level, climate change, the threat of increased variability in floods and droughts, and potential levee failure. (*Id*. at S-1.) The Table A amounts must be changed in the new contracts to reflect these challenges. DWR should conduct a full analysis of actual water supply availability, taking into account climate change, impacts to threatened and endangered species, public trust doctrine issues, and other environmental regulations and statutes, to determine realistic Table A amounts that can actually be delivered.

Despite this information, DWR excuses the use of the inflated Table A amounts as merely representing the maximum annual water delivery a contractor can request, and thus not guaranteed amounts. (DEIR at 7-3.) DWR therefore concludes that reducing Table A amounts proportionately for all the contractors by amendment would not change the amount of water being delivered to the contractors. (*Ibid*.) However, that conclusion is logically inaccurate and not supported by substantial evidence: reducing the Table A amounts would lower the maximum amount of water contractors could request each year, which in turn would lower the total amount of water DWR was contractually obligated to attempt to deliver. Setting Table A amounts at sustainable levels would also reduce the political and economic pressure on DWR to continually deliver water in excess of what the SWP system and the Bay-Delta ecosystem can handle.

The DEIR reasons that reducing Table A amounts would not change the financial health of the SWP because it would not affect any of the contract financial provisions that address SWP billing provisions and reimbursements. (*Id*. at 7-3 to 7-4.) DWR then rejected a reduction in Table A deliveries because it does not address the Project's financial objectives. (*Id*. at 7-4.) However, as the DEIR admits, proportionally reducing the Table A amounts can be accomplished without reducing the annual amounts paid by each contractor, or the total amount paid by all the contractors together (these figures are calculated proportionally, as a percentage of the total, not as fixed amounts per contractor). Thus, a reduction in Table A amounts is a clearly feasible and environmentally superior alternative. Not only can DWR meet all the objectives set forth above, it can also align the Project with the Delta Reform Act by ensuring a reliable and sustainable water supply to contractors and protecting, restoring, and enhancing the Bay-Delta ecosystem.

ii. Implement New Water Conservation Provisions in the Contracts.

Comments during the scoping also recommended that the EIR include an alternative that requires new agriculture and urban water conservation measures in the contract amendments, but DWR again rejected the alternative. (DEIR at 7-4.)

DWR reasoned that it does not have to evaluate the alternative because existing regulatory and legal requirements independent from the Project require agriculture and urban water efficiency, conservation, and management measures. (DEIR at 7-4.) According to the DEIR, federal, state, and local regulatory requirements are in place, and the contractors' water uses are governed by the Reasonable and Beneficial Use Doctrine. (*Ibid*.) The DEIR also states that Governor Brown issued Executive Order B-29-15, which requires stated mandatory water reductions from urban use. (*Ibid*.) Taking this into account, DWR concluded that additional water conservation measures would not address the financial challenges, nor would they make needed improvement to the current contract financial provisions, and therefore contract amendments with agriculture and urban water conservations measures were rejected for not meeting the basic project objectives. (*Ibid*.)

However, DWR fails to understand that the current federal, state, and local regulatory requirements are insufficient to protect and restore the Bay-Delta, which is exactly why the State Legislature determined that the Bay-Delta was in crisis and passed the Delta Reform Act. In fact, the Delta Plan promulgated pursuant to the Delta Reform Act specifically recommends DWR to include provisions "in all State Water Project contracts, contract amendments, contract renewals, and water transfer agreements that requires the implementation of all State water efficiency and water management laws, goals, and regulations, including compliance with Water Code § 85021," which requires California to reduce reliance on the Bay-Delta as a water supply. (Delta Stewardship Council, The Delta Plan (2013) ("Delta Plan") pp. ES-19, 103 (Attached as Exhibit B).) The impacts of water diversion and exports have environmental consequences beyond the Delta, impacting other hydrologically connected waters including the San Francisco Bay watershed. (See The Bay Institute, San Francisco Bay: the Freshwater-Starved Estuary (September 2016) p. 7 (Attached as Exhibit C).) The SWP's Banks Pumping Plant is one of the single largest extractors of the San Francisco Bay watershed's freshwater. (*Id*. at 9.) As a result of intensive water diversion and exports, on top of permanent drought conditions, the estuary and its unique and valuable fish and wildlife species have experienced extremely dry conditions throughout the past four decades. (*Id*. at 12.) The massive transformation of the Bay's watershed, including SWP pumping, has changed the patterns of flow resulting in a sharp decline of native fish. (*Id*. at 37.) Six native fish species—Delta smelt, longfin smelt, steelhead, green sturgeon, and the winter and spring runs of chinook salmon—used to be among the most common in the estuary but are now listed as in danger of extinction. (*Ibid*.)

By failing to include urban and agriculture conservation measures into the contracts, DWR is failing to comply with the Delta Plan and maintaining the same wasteful practices that caused the deterioration of the Bay-Delta. The conservation measures would not impact the financial provisions of the contract, meaning that DWR can meet all the projective objectives while also complying with the Delta Plan.

IV. CUMULATIVE IMPACTS

a. Failure to Disclose Reasonably Foreseeable Probable Future Projects.

A chief purpose of CEQA is providing public agencies and the general public with detailed information about the effects of a project on the environment. (*Bakersfield Citizens for Local Control v. City of Bakersfield* (2004) 124 Cal.App.4th 1184, 227.) Part of this vital informational function is performed by a cumulative impact analysis, which refers to when two or more individual effects which, when considered together, are considerable. (*Ibid*.) The cumulative impact is "the change in the environment which results from the incremental impact of the project when added to other closely related past, present, and reasonably foreseeable probable future projects." (*Ibid*.) An EIR must analyze all probable future projects, which includes any projects that are undergoing environmental review. (*Gray v. County of Madera* (2008) 167 Cal.App.4th 1099, 1127.) Moreover, agencies have a duty to "use its best efforts to find out and disclose all that it reasonably can." (S*an Franciscans for Reasonable Growth v. City of County of San Francisco, supra*, 151 Cal.App.3d at p. 74 [citing CEQA Guidelines, § 15140, subd. (g).].)

The DEIR concludes that the Water Supply Contract Extension Project will not result in physical environmental impacts, and therefore would not contribute to any cumulative effect, but DWR failed to analyze any reasonably foreseeable probable future projects. (DEIR at 6-4.) DWR proposed the Water Supply Contract Extension Project to affordably finance capital expenditures for the SWP because it is apparently difficult for DWR to sell revenue bonds used to finance the expenditures with maturity dates that extend beyond the year 2035. (DEIR at 4-1.) However, DWR has not described a single expenditure on the SWP that requires funding. Because DWR believes it needs more reliable funds to finance capital expenditures to the SWP, DWR must be aware of probable future expenditures, but has not disclosed what those expenditures are. DWR has a duty to disclose all that it reasonably can, and it is impossible to properly evaluate the environmental impacts of the Project without information regarding probable future projects that will use the funding enabled by this Project. DWR has therefore failed to conduct a proper cumulative impact analysis.

b. California WaterFix is a Reasonably Foreseeable Probable Future Project.

Despite its likely-insurmountable political and economic obstacles, and its dubious legality, California WaterFix qualifies as a reasonably foreseeable probable future project that will use SWP funding, and thus must be included in the DEIR's cumulative impacts analysis. (*Gray v. County of Madera*, *supra*, 167 Cal.App.4th at pp. 1127-1128 ["[A]ny future project where the applicant has devoted significant time and resources to prepare for any regulatory review should be considered a probable future project for the purposes of the cumulative impact].) DWR has prepared a Recirculated Draft Environmental Impact Report/Supplemental Draft Environmental Impact Statement ("RDEIR/SDEIS") that purports to address the impacts of California WaterFix, making it a probable future project, yet information about this project is not sufficiently included in the DEIR. (DEIR at 7-5.) The DEIR concludes that since California WaterFix is separate and independent, and the contract extension would need to occur regardless of California WaterFix, it need not be included in the EIR. (*Ibid*.) Yet CEQA requires that the DEIR analyze all future probable projects.

Moreover, since the purpose of the Project is to enable DWR to finance SWP expenditures beyond 2035, and California WaterFix is an SWP expenditure, the funds will likely be used to pay for California WaterFix. (DEIR at 7-5.) Even in the unlikely event that California WaterFix obtains final approval, the Water Supply Contract Extension Project appears to exist for the purpose of funding California Waterfix, and DWR must therefore include California WaterFix in its cumulative impact analysis. In fact, California WaterFix, due to its extremely large capital cost, likely could not move forward without the completion of this contract extension. This is even more apparent when considering the removal of Article hh, which required that SWP revenue bonds be used to finance repairs to facilities that existed prior to January 1, 1987 and only be used to repair listed capital projects. (DEIR at 4-5.) The Water Supply Contract Extension Project proposes to delete the only clause that limits the extent of Delta Transfer Facilities that DWR could pursue after 1987. By removing Article hh, DWR would pave the way to finance California WaterFix with revenue bonds, which is prohibited in the current contracts.

V. CONCLUSION

DWR should not certify the DEIR or approve the Water Supply Contract Extension Project without conforming the Project to the Delta Policy, properly analyzing environmentally superior alternatives, and evaluating reasonably foreseeable probable future projects, including California WaterFix.

Thank you for the opportunity to comment on this matter. We look forward to your consideration and response to these comments.

Sincerely,

Ryan Berghoff
Center for Food Safety

Exhibit A

to Comments on the Department of Water Resources Draft Environmental Impact Report for the Water Supply Contract Extension Project

The State Water Project

Final Delivery Reliability Report 2011

June 2012

State of California
Natural Resources Agency
Department of Water Resources

Individuals contributing to the development of the report

John Leahigh, Principal Engineer, Division of Operations and Maintenance
Sushil Arora, Supervising Engineer, Bay-Delta Office
Dustin Jones, Senior Engineer, Bay-Delta Office
Aaron Miller, Senior Engineer, Division of Operations and Maintenance
Erik Reyes, Senior Engineer, Bay-Delta Office
Sina Darabzand, Senior Engineer, Bay-Delta Office
Alan Olson, Engineer, Bay-Delta Office
Christopher Quan, Engineer, Bay-Delta Office
Daniel Teixeira, Staff Services Analyst, Administrative and Executive Services Office

Prepared by AECOM

Director's Message

The *State Water Project Delivery Reliability Report 2011* (2011 Report) is the latest update to a biannual report that describes the existing and future conditions for State Water Project (SWP) water supply that are expected if no significant improvements are made to convey water past the Sacramento–San Joaquin Delta (Delta) or to store the more variable runoff that is expected with climate change.

This report is presented in a different format than previous versions. The four previous reports were written for a dual audience—both the general public and those interested in a greater level of technical detail, such as the SWP contractors. By contrast, this report is written primarily with the public in mind. As a result, it not only provides updated information about the SWP's water delivery reliability, but is also designed to educate Californians about the SWP and its operations. This report presents a concise description of the historical events leading to the construction of the SWP and describes the SWP's facilities and operations. It then defines and explains the concept of water delivery reliability and the types of SWP water available to contractors, and describes various factors that affect the reliability of water deliveries. Because of the public interest in water project pumping from the Delta and the dependence of SWP water supply on Delta pumping, a new chapter has been added that focuses specifically on SWP pumping (exports) at the Harvey O. Banks Pumping Plant in the Delta.

The 2011 Report shows that the SWP continues to be subject to reductions in deliveries similar to those contained in the *State Water Project Delivery Reliability Report 2009* (2009 Report), caused by the operational restrictions of biological opinions (BOs) issued in December 2008 and June 2009 by the U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) to govern SWP and Central Valley Project operations. Federal court decisions have remanded the BOs to USFWS and NMFS for further review and analysis. We expect that the current BOs will be replaced sometime in the future. The operational rules defined in the 2008 and 2009 BOs, however, continue to be legally required and are the rules used for the analyses supporting the 2011 Report.

The following "Summary" includes key findings of the analyses in the 2011 Report. A technical addendum is also available which provides detail on the assumptions of the analyses and the results for the 2011 Report. The results of the studies, as presented in this report and the technical addendum, are designed to assist water planners and managers in updating their water management and infrastructure development plans. These results emphasize the need for local agencies to develop a resilient and robust water supply, and a distribution and management system to maximize the efficient use of our variable supply. They also illustrate the urgent need to improve the method of conveying water past the Delta in a more sustainable manner that meets the dual goals of increasing water delivery reliability and improving conditions for endangered and threatened fish species.

Mark Cowin
Director
California Department of Water Resources
June 2012

Summary





This report is intended to inform the public about key factors important to the operation of the SWP and the reliability of its water deliveries.

California faces a future of increased population growth coupled with the potential for water shortages and pressures on the Delta. For many SWP water contractors, water provided by the SWP is a major component of all the water supplies available to them. SWP contractors include cities, counties, urban water agencies, and agricultural irrigation districts. These local utilities and other public and private entities provide the water that Californians use at home and work every day and that helps to nourish the state's bountiful crops. Thus, the availability of water to the SWP becomes a planning issue that ultimately affects the amount of water that local residents and communities can use.

The availability of these water supplies may be highly variable. A wet water year may be followed by a dry or even critical year. Knowing the probability that they will receive a certain amount of SWP water in a given year—whether it be a wet water year, a critical year, or somewhere in between—gives contractors a better sense of the degree to which they may need to implement increased conservation measures or plan for new facilities.

The Delta is the key to the SWP's ability to deliver water to its agricultural and urban contractors. All but three of the 29 SWP contractors receive water deliveries from the Delta (pumped by either the Harvey O. Banks or Barker Slough Pumping Plant).

Yet the Delta faces numerous challenges to its long-term sustainability. Among these are continued subsidence of Delta islands, many of which are already below sea level, and the related threat of a catastrophic levee failure as water pressure increases on fragile levees. Climate change poses the threat of increased variability in floods and droughts, and sea level rise complicates efforts to manage salinity levels and preserve water quality in the Delta so that the water remains suitable for urban and agricultural uses.

Protection of endangered and threatened fish species, such as the delta smelt, is also an important factor of concern for the

Delta. Ongoing regulatory restrictions, such as those imposed by federal biological opinions on the effects of SWP and CVP operations on these species, also contribute to the challenge of determining the SWP's water delivery reliability.

The analyses in this report factor in all of the regulations governing SWP operations in the Delta and upstream, and assumptions about water uses in the upstream watersheds.

Modeling was conducted that considered the amounts of water that SWP contractors use and the amounts of water they choose to hold for use in a subsequent year.

Many of the same specific challenges to SWP operations described in the *State Water Project Delivery Reliability Report 2009* (2009 Report) remain in 2011. Most notably, the effects on SWP pumping caused by issuance of the 2008 and 2009 federal biological opinions, which were reflected in the 2009 Report, continue to affect SWP delivery reliability today. The analyses in this report factor in climate change and the effects of sea level rise on water quality, but do not incorporate the probability of catastrophic levee failure. The resulting differences between the 2009 and 2011 Reports can be attributed primarily to updates in the modeling assumptions and inputs.

As noted in the discussion of SWP exports in Chapter 5 of this report, Delta exports (that is, SWP water of various types pumped by and transferred to contractors from the Banks Pumping Plant) have decreased since 2005, although the bulk of the change occurred by 2009 as the federal BOs went into effect, restricting operations. These effects are also reflected in the SWP delivery estimates provided in Chapters 6 and 7 of this report. Chapters 6 and 7 characterize the SWP's water delivery reliability under existing conditions and future conditions, respectively. The following are a few of the key points from Chapters 5, 6, and 7:

- Estimates of average annual SWP exports under conditions that exist for 2011 are 2,607 thousand acre-feet (taf), 350 taf or 12% less than the estimate under 2005 conditions.
- The estimated average annual SWP exports decrease from 2,607 taf/year to 2,521 taf/year (86 taf/year or about 3%) between the existing- and future-conditions scenarios.
- The estimates in this report for Table A water supply deliveries are not significantly different from those in the 2009 Report. The average annual delivery estimated for existing conditions (2,524 taf/year) is 2% greater, and the estimated amount for future conditions (2,466 taf/year) is 1% less than the corresponding estimates in the 2009 Report.
- The likelihood of SWP Article 21 deliveries (supplemental deliveries to Table A water) being equal to or less than 20 taf/year has increased relative to that estimated in the 2009 Report. However, both this report and the 2009 Report show a high likelihood that Article 21 water deliveries will be equal to or less than 20 taf/year, ranging between 71% and 78% for both existing and future conditions.

Table of Contents

Tables

Page

Figures

Page

Chapter 1

Water Delivery Reliability: A Concern for Californians

California's water supplies are crucial to maintaining a high quality of life for the state's residents. The State Water Project (SWP), operated by the California Department of Water Resources (DWR), is an integral part of the effort to ensure that business and industry, urban and suburban residents, and farmers throughout much of California have sufficient water at all times. This *State Water Project Delivery Reliability Report 2011* describes the expected existing and future SWP water deliveries.

The term "water delivery reliability," as used in this report, is defined as the annual amount of SWP water that can be expected to be delivered with a certain frequency. To put this another way: What is the likelihood, or probability, that a certain amount of water will be delivered by the SWP in a year?

Reasons to Assess SWP Water Delivery Reliability

Let's look at two important factors that underscore the importance of assessing the SWP's water delivery reliability: the effects of population growth on California's water supply, and State legislation intended to help maintain a reliable water supply.

Population Growth, Land Use, and Water Supply

Water and development have had a close yet complex relationship since California's early days. Indeed, the SWP was established in the wake of a second economic "gold rush" that began after the end of World War II. Increased statewide population and commerce made it clear to water managers that local water supplies (including groundwater) would not be sufficient to meet their communities' future needs.

Population growth and resulting development in California since World War II have been substantial, fueling the need for increased water supply.

California's population has grown rapidly in recent years, with resulting changes in land use. This growth is expected to continue. From 1990 to 2005, California's population increased from about 30 million to about 36.5 million. Based on this trend, California's population has been projected to be more than 47.5 million by 2020. The "current trends" scenario depicted in the *California Water Plan 2009* for year-2050 conditions assumed a population of nearly 60 million—double the 1990 population.

The amount of water available in California—or in different parts of the state—can vary greatly from year to year. Some areas may receive 2 inches of rain a year, while others are deluged with 100 inches or more. As land uses have changed, population centers have grown up in many locations where there is not a sufficient local water supply. Thus, Californians have always been faced with the problem of how best to conserve, control, and move water from areas of abundant water to areas of water need and use.

To help assure that their water supply is sufficient to meet their demands, water districts develop "water management portfolios" that reflect diversity in water sources and locations. Components of a sustainable water portfolio include conservation, improved efficiency in use, rainwater and runoff capture, use of groundwater aquifers for storage and treatment, improved water treatment, desalination, and a water recycling program.

Legislation on Ensuring a Reliable Water Supply

The laws described below impose specific requirements on both urban and agricultural water suppliers. These laws increase the importance to water suppliers of estimates of SWP water delivery reliability.

California Urban Water Management Planning Act

The California Urban Water Management Planning Act was enacted in 1983. As amended, this law (California Water Code, Sections 10610–10656) requires urban water suppliers to adopt water management plans every 5 years and submit those plans to DWR. Adoption of the most recent (2010) round of urban water management plans was required by July 1, 2011; the plans were due to DWR by August 1, 2011.

In their water management plans, urban water suppliers must assess whether their current and planned water supplies will be enough to meet the water demands expected during the next 20 years. The plans also consider various drought scenarios and the proper ways to respond in case of an unexpected water shortage.

DWR is required to review local water management plans and report on the status of these plans. DWR published a guidebook to preparing urban water management plans in March 2011. Guidance documents are available at http://www.water.ca.gov/urbanwatermanagement.

Water Conservation Act

The Water Conservation Act of 2009 (Senate Bill X7.7, Steinberg), enacted in November 2009, includes distinct requirements related to both urban and agricultural water use.

This law requires that the State of California reduce urban per capita water use statewide by 10% by the end of 2015 and 20% by the end of 2020. DWR is required to report on progress toward meeting these urban per capita water use goals.

In addition, agricultural water suppliers must adopt agricultural water management plans by the end of 2012, then update the plans by the end of 2015 and every 5 years thereafter.

Through its Agricultural Water Management Planning & Implementation Program (http://www.water.ca.gov/wateruseefficiency/agricultural/agmgmt.cfm), DWR helps water districts develop agricultural water management plans and implement cost-effective, efficient water management practices. DWR is currently preparing a guidebook for developing agricultural water management plans.

Background of This Report

This *State Water Project Delivery Reliability Report 2011* is the fifth in a series of reports on the SWP's water delivery reliability. DWR is legally required to prepare and distribute this report every 2 years to all SWP contractors (recipients of SWP water), city and county planning departments, and regional and metropolitan planning departments in the SWP's service area. Reports were previously produced for 2002, 2005, 2007, and 2009.

The requirement for a biennial water delivery reliability report was established in a settlement agreement among the Planning and Conservation League, DWR, SWP contractors, and others that was approved by the 3rd Circuit Court of Appeals in May 2003. The settlement agreement was reached in the aftermath of the "Monterey Amendments" case, which resolved a dispute about the environmental analysis of amendments to the long-term water supply contracts for the SWP that were entered into by DWR and most of the SWP contractors in the 1990s. The terms of the SWP contracts were amended after water shortages during the 1987–1992 drought drastically reduced SWP water deliveries to SWP contractors in the San Joaquin Valley and Southern California.

Attachment B to the settlement agreement specifies that each SWP delivery reliability report must include all of the following information:

- the overall water delivery capacity of the SWP facilities at the time of the report;
- the allocation of that SWP water to each SWP contractor;
- a discussion of the range of hydrologic conditions, which must include the historic extended dry cycle and long-term average; and
- the total amount of SWP water delivered to all contractors and the amount of SWP water delivered to each contractor during each of the 10 years immediately preceding the report.

DWR's water delivery reliability reports are used by various entities for water planning purposes. The reports must be presented in a format understandable by the public. The information presented in the reports is intended to help local agencies, cities, and counties that use SWP water to develop adequate, affordable water supplies for their communities.

Contents and Use of This Report

The following topics are addressed in this *State Water Project Delivery Reliability Report 2011*:

- The Summary at the front of this report briefly summarizes the updated findings on water delivery reliability detailed in previous chapters.
- Chapter 1, "Water Delivery Reliability: A Concern for Californians," summarizes important issues (including selected State legislation) that underlie the need to assess the SWP's water delivery reliability, provides background on DWR's water delivery reliability reports, and defines key terms.
- Chapter 2, "A Closer Look at the State Water Project," describes the SWP's purpose, background, and facilities. This chapter also introduces factors that interact in the Sacramento–San Joaquin Delta (Delta) to affect SWP operations: precipitation and snowmelt patterns, variable river inflows, operations of the federal Central Valley Project (CVP), Delta water quality concerns, regulatory requirements, and the Delta's physical conditions.
- Chapter 3, "SWP Contractors and Water Contracts," lists the SWP water contractors and shows where they are located, and describes the different types of SWP water allocations.
- Chapter 4, "Factors that Affect Water Delivery Reliability," explains generally how water delivery reliability is calculated. The chapter then describes a variety of factors that make forecasting water delivery

reliability inherently challenging. Among these complicating factors are climate change, environmental and policy planning efforts pertaining to the Delta, and the potential for levee breaches in the Delta.

- Chapter 5, "SWP Delta Exports," discusses how the delivery estimates for the SWP have been reduced as a result of more restrictive operational rules. This chapter also presents the results of DWR's modeling of SWP exports from the Harvey O. Banks Pumping Plant for existing conditions (2011) and future conditions (2031).
- Chapter 6, "Existing SWP Water Delivery Reliability (2011)," estimates the SWP's delivery reliability for existing conditions (2011) and compares these estimates with the existing-condition results presented in the *State Water Project Delivery Reliability Report 2009*.
- Chapter 7, "Future SWP Water Delivery Reliability (2031)," estimates the SWP's delivery reliability for conditions 20 years in the future (2031), reflecting potential hydrologic changes that could result from climate change. This chapter also compares these estimates with the future-condition results presented in the *State Water Project Delivery Reliability Report 2009*.
- Appendix A, "Historical SWP Delivery Tables for 2001–2010," presents the historical deliveries for SWP contractors over the last 10 years.

In addition, a technical addendum has been prepared for this report and includes more specific details of the technical analyses and results. Urban and agricultural water suppliers can use the information in this report and the technical addendum when they prepare or amend their water management plans. These details will help them decide whether they need new facilities or programs to meet future water demands. The technical addendum is available upon request and is posted online, along with this report, at http://baydeltaoffice.water.ca.gov.

Urban water suppliers can also use this information when, as required by the California Environmental Quality Act, they analyze whether enough water is available for proposed subdivisions or development projects.





Chapter 2

A Closer Look at the State Water Project

Northern California typically receives abundant rainfall and runoff from mountain snowpack. However, a larger percentage of California's population lives in Southern California and most irrigated farmland lies in Central California. These regions are mostly arid, and local water suppliers cannot fully meet the needs of many of their communities. These areas rely on additional imported water, especially to meet shortages during dry years and the demands of increasing populations. The SWP was constructed to help meet these needs.

Purpose and Background of the SWP

The SWP is the largest state-built, multipurpose, user-financed water project in the United States. More than two-thirds of California's residents—25 million people—receive at least part of their water from the SWP. Project water also supplies thousands of industries and irrigates about 750,000 acres of California farmland. Of the SWP's contracted water supply, 70% goes to urban users and 30% goes to agricultural users.

The primary purpose of the SWP is to provide a water supply—that is, to divert and store water during wet periods in Northern and Central California and distribute it to areas of need in Northern California, the San Francisco Bay area, the San Joaquin Valley, the Central Coast, and Southern California. Other SWP purposes include flood control, power generation, recreation, fish and wildlife enhancement, and water quality improvement in the Delta.

These purposes have been discussed at length for many decades. The concept of a statewide water development project was first raised in 1919 when Lt. Robert B. Marshall of the U.S. Geological Survey proposed transporting water from the Sacramento River system to the San Joaquin Valley, then moving it over the Tehachapi Mountains into Southern California.

In the 1930s, State Engineer Edward Hyatt proposed the "State Water Plan," which identified the facilities needed and economic means to transfer water from north to south. The California Legislature authorized the project in the Central Valley Act of 1933, and a $170 million bond act was approved by California voters in December 1933. However, the Great Depression precluded the State from obtaining the necessary funding. The U.S. government funded the construction of major components of the plan, which became the federal CVP. (See "The Central Valley Project and Its Relationship to the SWP" later in this chapter.)

As California's population grew after World War II, investigations of statewide water resources resumed. In 1945, DWR's predecessor, the Division of Water Resources of the Department of Public Works, conducted a variety of studies that culminated in the Feather River Project, presented to the State Legislature in 1951 by State Engineer A. D. Edmonston. A revised project proposal was presented in 1955. The Legislature appropriated funds for detailed studies of the Feather River Project, which evolved to become the SWP.

In 1959, the Legislature passed the California Water Resources Development Bond Act. This law, also known as the Burns-Porter Act, authorized $1.75 billion in bonds to build the SWP's initial facilities, contingent on voter approval. After California voters approved the Burns-Porter Act in November 1960, construction of the SWP by DWR began in the early 1960s, with water deliveries following.

SWP Facilities

Today, the SWP includes 33 storage facilities, 21 reservoirs and lakes, 20 pumping plants, four pumping-generating plants, five hydroelectric power plants, and about 700 miles of canals and pipelines. Figure 2-1 shows the primary SWP facilities.

Facilities North of the Delta

The SWP's watershed encompasses the mountains and waterways around the Feather River in Plumas County. Rain and melting snow run off mountainsides and into waterways that flow into Lake Oroville, where the SWP officially begins. With a capacity of about 3.5 million acre-feet, Lake Oroville is the SWP's largest storage facility. The water management facilities of Lake Oroville are designed to maximize energy production and include six power generating units and six pumping/generating units. Three hydroelectric power plants operate at Oroville.

Oroville Dam.

When water is needed, Oroville Dam releases water into the Feather River, which converges with the Sacramento River north of the city of Sacramento. Releases from Shasta and Folsom Reservoirs, facilities of the federal CVP, also flow into the Sacramento River. The Sacramento River flows into the Delta, where it mixes with water from the San Francisco Bay and is influenced by the tides. From the Delta, some of this water is pumped by the Barker Slough Pumping Plant into the North Bay Aqueduct for municipal use by Napa and Solano Counties.

Figure 2-1. Primary State Water Project Facilities

Facilities in the Delta and Central California

The SWP's primary pumping plant, the Harvey O. Banks Pumping Plant, is located in the south Delta in Alameda County. The pumps at the Banks Pumping Plant lift Delta water stored in the Clifton Court Forebay into the California Aqueduct, which at 444 miles long is the longest water conveyance system in California. At Bethany Reservoir, some SWP water is diverted from the California Aqueduct into the South Bay Aqueduct, which serves urban and agricultural uses in Alameda and Santa Clara Counties.

Harvey O. Banks Pumping Plant.

Water in the California Aqueduct flows into the San Luis Joint-Use Complex located in Merced County, which is jointly owned by the SWP and the CVP. Among the facilities at the complex is San Luis Reservoir, which is the world's largest offstream reservoir, with storage space for more than 2 million acre-feet of water. (An "offstream reservoir" is a water body that does not impede and store natural flows directly within a stream course, but instead is located "offstream"; stored water is diverted elsewhere and conveyed to the offstream reservoir by a pipeline or aqueduct.) Generally, water is pumped into San Luis Reservoir from late fall through early spring and is stored temporarily before being released back to the California Aqueduct to meet the higher summertime water demands of SWP (and CVP) contractors.

Facilities in the San Joaquin Valley and Southern California

After leaving the San Luis Joint-Use Complex, water travels through the central San Joaquin Valley via a jointly owned federal/State portion of the California Aqueduct. Along the way, deliveries are made to San Joaquin Valley contractors of both the SWP and the CVP. Near Kettleman City in Kings County, the SWP's Coastal Branch Aqueduct branches off to serve SWP contractors in San Luis Obispo and Santa Barbara Counties. The California Aqueduct continues southeast until, at the base of the Tehachapi Mountains, it reaches the A. D. Edmonston Pumping Plant, the SWP's largest pumping station.

A. D. Edmonston Pumping Plant.

The Edmonston Pumping Plant, located in Kern County, is an engineering marvel. It is the highest single-lift pumping plant in the world. The 14 pumps at this facility, each weighing more than 400 tons and powered by 80,000-horsepower motors, raise water from the California Aqueduct 1,926 feet—more than one and one-half times the height of New York's Empire State Building—to enter 10 miles of tunnels and siphons that cross the Tehachapi Mountains.

After crossing the mountains, the water splits into two branches, the West Branch and East Branch, and is delivered to SWP contractors in Southern California. The southernmost SWP facility, located at the end of the East Branch, is Lake Perris in Riverside County.

The Delta and Factors Affecting SWP Operations and Deliveries

The Delta forms the eastern portion of the San Francisco estuary. It is composed of 738,000 acres of land interlaced with hundreds of miles of waterways that receive runoff from about 40% of the state's land area. The Delta is one of the few estuaries in the world that is used as a major source of drinking water supply. The Delta is important not only to SWP operations, but to California's economy. About $400 billion of California's $1.5 trillion economy is supported by water from the Delta, as noted by DWR and the California Department of Fish and Game (DFG) in the 2008 report, *Risks and Options to Reduce Risks to Fishery and Water Supply Uses of the Sacramento/San Joaquin Delta*.

Numerous competing demands converge in the Delta—especially the need to provide water for both agricultural and urban uses and the desire to protect habitat for endangered species.

In the SWP conveyance system, the Delta is the critical link between the water supplies in the Sacramento Valley and the water demands of, and deliveries to, the rest of the Central Valley and Southern California. Physically, the Delta is the focal point for water distribution in California because most of the SWP contractors are located at points south of the Delta.

However, the Delta has long been an area of numerous competing demands; for example, the Delta provides water for millions of Californians, but also serves as important habitat for hundreds of animal, plant, and fish species, some of which are listed under the federal Endangered Species Act (ESA) and/or California Endangered Species Act (CESA) as threatened or endangered. It also supports a local population of more than 500,000 and millions of visitors who use the Delta's recreational areas, navigable waterways, and marinas. Further, not only do SWP and CVP contractors use Delta water for agriculture, but local farmers within the Delta itself use its water to irrigate their crops planted on the numerous Delta islands.

The SWP's ability to pump water from the Delta is not affected only by the physical size and capacity of the pumps at the Banks Pumping Plant. As described below, the Delta is affected by numerous factors that interact to affect SWP operations and water deliveries:

- Delta inflows (i.e., the combined total of water flowing into the Delta from the Sacramento River, San Joaquin River, and other rivers and waterways),
- beneficial uses and water rights,
- Delta water quality standards,
- regulatory requirements,
- concurrent CVP operations and pumping, and
- physical factors.

Delta Inflows

Delta inflow varies considerably from year to year. Levels of development upstream of the Delta along the rivers and their watersheds—in the areas from which the water originates—affect Delta inflows. For example, in an above-normal year, nearly 85% of the total Delta inflow comes from the Sacramento River, more than 10% comes from the San Joaquin River, and the rest comes from three eastside streams (the Mokelumne, Cosumnes, and Calaveras Rivers) (Figure 2-2).

The type of water year is also an important factor affecting the volume of Delta inflows. When hydrology is analyzed, water years are designated by DWR as “wet,” “above normal,” “below normal,” “dry,” or “critical” based on the amount of rain and snow that fell during the preceding period of October 1–September 30. DWR hydrologists and meteorologists measure snowpack in the northern Sierra Nevada on or about the first of January, February, March, April, and May, in the watersheds where most of the state’s water supply originates, to forecast snowmelt runoff—and thus available water supply—for the coming spring and summer.

All other factors (such as upstream development) being equal, much less water will flow into the Delta during a dry or critical water year—that is, during a drought—than during a wet or above normal water year. Fluctuations in inflows are a substantial overall concern for the Delta, and a specific concern for the SWP; such fluctuations affect Delta water quality and fish habitat, which in turn trigger regulatory requirements that constrain SWP Delta pumping. For example:

- As discussed below under “Delta Water Quality Standards,” lower inflows can cause Delta water to become increasingly saline and trigger additional upstream reservoir releases and/or reduced Delta pumping to meet regulatory requirements.
- Conditions for fish in the Delta are less suitable in drier years, as seen during California’s 1987–1992 drought, which can also trigger regulatory requirements that reduce SWP pumping.

Delta inflows will also vary by time of year because the amount of precipitation varies by season. About 80% of annual precipitation occurs between November and March, and very little rain typically falls from June through September. A seasonal mismatch of water supply and demand typically exists; runoff is greatest in winter and spring, but water demands peak in summer. Upstream reservoirs dampen this variability by reducing flood flows and storing water to be released later in the year to meet water demands and flow and water quality requirements.

Delta Water Quality Standards

Water quality standards for the Delta also affect SWP operations. The Porter-Cologne Water Quality Control Act (Division 7 of the California Water Code) defines “beneficial uses” of waters of the State (both surface water and groundwater) that must be protected against quality degradation. These beneficial uses include domestic, municipal, agricultural, and industrial supply; power generation; recreation; aesthetic enjoyment; navigation; and preservation and enhancement of fish, wildlife, and other aquatic resources or preserves. The criteria based on those uses, called “water quality objectives,” are found in the water quality control plans adopted by the State Water Resources Control Board and the nine regional water quality control boards. The SWP and CVP must meet specific criteria for salinity during certain times of the year at various locations in the Delta, as described further under “Factors that Can Influence the SWP’s Water Delivery Reliability” in Chapter 4.

Salinity levels can be affected by the water year type: Inflows into the Delta decline in dry and

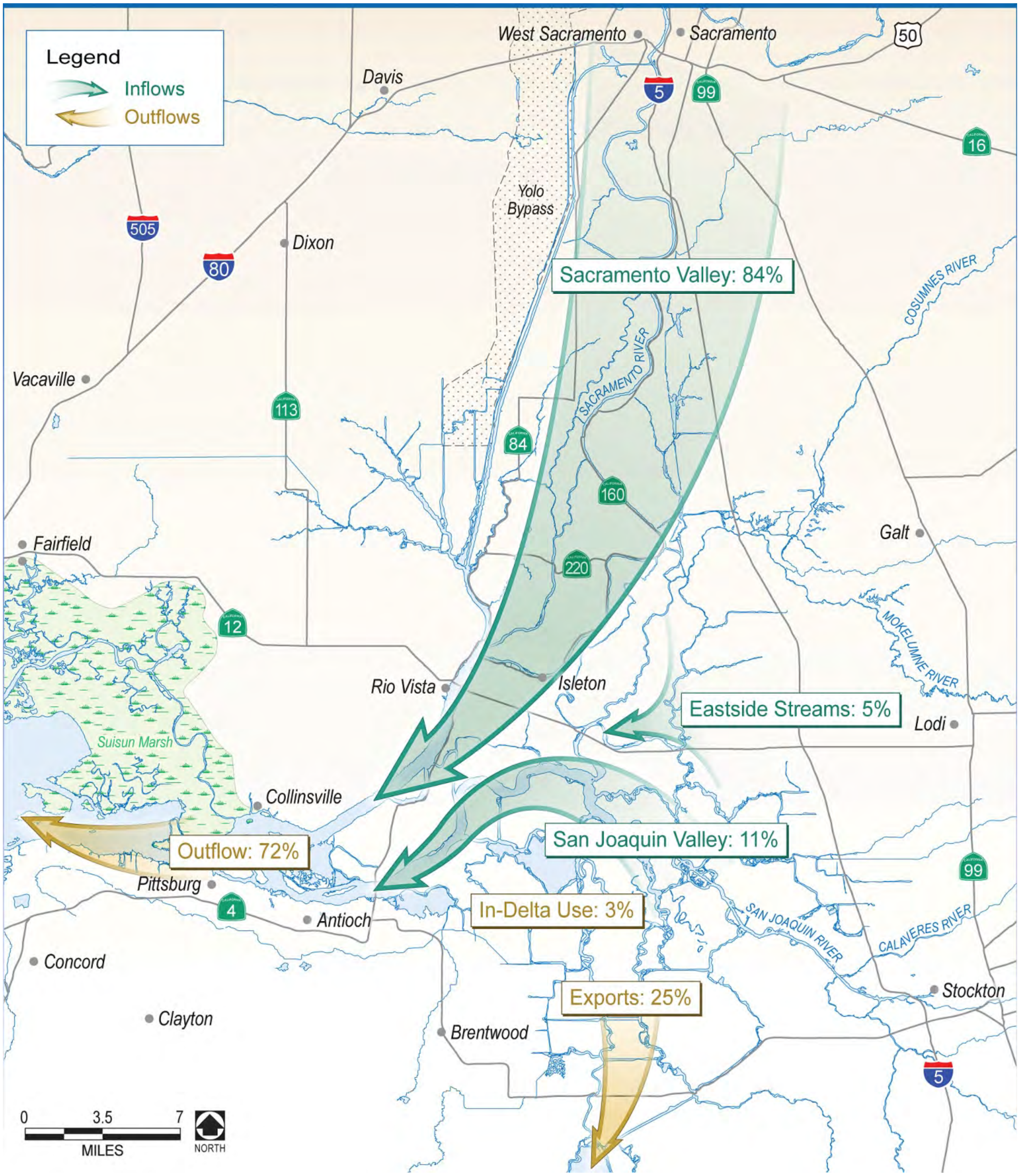


Figure 2-2. Water Year 2000 (Above-Normal) Delta Water Balance (Percent of Total)

critical water years, but daily tidal inflow of salty water into the Delta from the Pacific Ocean remains generally the same, thus increasing Delta salinity. Excessive salinity may adversely affect crop yields and require more water for salt leaching, may require additional municipal and industrial treatment, may increase salinity levels in agricultural soils and groundwater, and is the primary water quality constraint to recycling wastewater. Salty water is both undrinkable and unusable for irrigation (and thus unsuitable for SWP and CVP contractors and farmers in the Delta), and is harmful to fish inhabiting the Delta, including endangered and threatened species. Climate change is also causing sea level rise, which is projected to substantially increase Delta salinities. Generally, Delta water quality is best during winter and spring and poorer through the summer irrigation season and early fall.

SWP operations are closely regulated by the water quality standards contained in State Water Resources Control Board Water Right Decision 1641 (D-1641). D-1641 was issued in December 1999 (with a revised version issued in March 2000) to implement the 1995 *Water Quality Control Plan for the San Francisco Bay/Sacramento–San Joaquin Delta* (1995 WQCP). The 1995 WQCP established beneficial uses of Delta water, associated water quality objectives for the reasonable protection of beneficial uses, and an implementation program to achieve the water quality objectives.

D-1641 assigned primary responsibility for meeting many of the water quality objectives established in the 1995 WQCP to the SWP (thus, to DWR) and the CVP (thus, to Reclamation). To meet these objectives, D-1641 limits or curtails SWP and CVP pumping operations in certain parts of the year. For example, D-1641 imposed limits on the ratio of SWP and CVP exports to total inflow into the Delta. This "export-inflow ratio" varies by time of year.

Regulatory Requirements

The Delta provides important habitat for fish species listed as threatened or endangered under either the federal ESA or the CESA, or both. Several resource agencies have taken actions under their authorities to protect these species. Regulatory requirements based on recent biological opinions (BOs) issued by the U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) for CVP and SWP operations are a particularly important factor affecting SWP operations. DFG also regulates the protection of species under the CESA, and has issued consistency determinations in the past when it has found federal BOs to be consistent with CESA for State-listed species.

Delta smelt.

A BO is a determination by USFWS or NMFS on whether a proposed federal action is likely to jeopardize the continued existence of a threatened or endangered species or result in the destruction or adverse modification of designated critical habitat. If jeopardy is determined, certain actions are required to protect species of concern. Usually BOs apply specifically to federal actions, but DWR coordinates with Reclamation in the agencies' operation of the SWP and federal CVP. Since the passage of the federal ESA in 1973, various BOs have been issued by USFWS and NMFS for the effects on federally listed endangered species of these coordinated operations.

NMFS administers the ESA for marine fish species, including anadromous salmonids (those that spend a part of their life cycle in the sea and return to freshwater streams to spawn), such as

Central Valley steelhead, winter-run and spring-run Chinook salmon, and green sturgeon. USFWS administers the ESA for nonanadromous and nonmarine fish species, such as delta smelt and longfin smelt. Both anadromous and nonanadromous fish species are found in the Delta and are federally listed under the ESA.

If USFWS or NMFS finds that a proposed action is likely to jeopardize a listed species or adversely modify its critical habitat, the agency is required to identify "reasonable and prudent alternatives" (defined in Title 50, Section 402.02 of the Code of Federal Regulations) that it has determined would enable the project to go forward in compliance with the ESA.

Especially important to the SWP are the BOs issued by USFWS and NMFS in 2008 and 2009, respectively, for the coordinated operations of the CVP and SWP. Both of these BOs, which DFG found consistent with the CESA for State-listed species, have directly and substantially affected SWP operations and pumping levels in recent years: They incorporate terms that directly or indirectly limit the amount of CVP and SWP Delta pumping under certain conditions. Relative to prior years, SWP water deliveries estimated in the *State Water Project Delivery Reliability Report 2009*—the last edition of this report—were, in general, reduced by the operational restrictions of these BOs.

Concurrent Central Valley Project Operations and Pumping

CVP operations also affect the Delta as Reclamation diverts water for agricultural and urban uses. To make the most efficient use of the common water supply available to the CVP and SWP, Reclamation and DWR must work as closely as possible to coordinate their respective reservoir releases and Delta pumping operations. The CVP and SWP operate in conjunction according to the Coordinated Operation Agreement signed in 1986 by the two agencies.

Subsidence (sinking) of islands in the Delta places even more pressure on already fragile Delta levees.

The two projects share some of their facilities in the San Joaquin Valley—most notably the San Luis Unit, for which the major storage reservoir is San Luis Reservoir, and more than 100 miles of the California Aqueduct. In addition, the CVP and SWP are allowed to use each other's export pumping facilities in the south Delta—to pump water for each other—when operation of one set of pumps is affected by facility maintenance, capacity limitations, or fish protection requirements. Use of this "joint point of diversion" is subject to an operations plan that protects fish and wildlife and other legal users of water.

Physical Factors

The stability and reliability of SWP water deliveries can be threatened by physical factors affecting facilities or water quality anywhere in the SWP system. The Delta is particularly vulnerable. Delta islands have been subsiding and in some places the land has sunk to 20 feet below sea level. This places extra pressure on the Delta's levees because it means they must hold back water constantly rather than only during peak-flow periods.

Climate change is causing sea level to rise, increasing pressure on Delta levees even further. Delta levees are also vulnerable because they were built 150 years ago and could be affected if an earthquake were to strike anywhere near the Delta.

THE CENTRAL VALLEY PROJECT AND ITS RELATIONSHIP TO THE SWP

The federal Central Valley Project, operated by the U.S. Bureau of Reclamation, was originally conceived as a State of California project to protect the Central Valley from water shortages and floods. During the Great Depression, however, the State was unable to sell bonds to finance project construction, and beginning in the late 1930s, the U.S. government constructed the CVP as a public works project.

The CVP operates 18 dams and reservoirs, 11 powerplants, and 500 miles of canals and other facilities between the Cascade Range near Redding and the Tehachapi Mountains near Bakersfield. It serves agricultural, municipal, and industrial needs in the Central Valley and urban centers in parts of the San Francisco Bay Area, and is the primary water source for many Central Valley wildlife refuges. In an average year the CVP delivers about 7 million acre-feet of water for agriculture, urban, and wildlife use, irrigating about one-third (3 million acres) of California's agricultural lands and supplying water for nearly 1 million households (Reclamation 2009).

The CVP and SWP share some of their facilities, especially the San Luis Unit, and their respective operations staffs work closely together. The Coordinated Operations Agreement between the CVP and SWP, signed in 1986, outlines the shared responsibilities of each project to meet Delta water quality and flow objectives and provides for equitable sharing of surplus water that enters the Delta.

Chapter 3

SWP Contractors and Water Contracts





During the 1960s, as the SWP was created, long-term contracts were signed by DWR and 29 urban and agricultural water suppliers in various locations within California. The contracts are essentially uniform and will expire in 2035. These urban and agricultural water suppliers are referred to in this report as the "SWP contractors" or "contractors." This chapter introduces the SWP contractors, explains the basics of SWP water contracts, and describes the various types of project water, especially "Table A" water. The discussion also outlines some of the factors that influence delivery of Table A water.

About the SWP Contractors

The SWP contractors are located along the Feather River north of the Delta, in the north and south San Francisco Bay Area, along the Central Coast, in the San Joaquin Valley, and in Southern California. They include cities, counties, urban water agencies, and agricultural irrigation districts. Most contractors use the project water they receive for municipal purposes; several use the water for agriculture. The SWP contractors mostly use project water to supplement local supplies, including groundwater, or other imported water. The 29 SWP contractors are listed below and their locations are shown in Figure 3-1.

Feather River Area Contractors

- Butte County
- Yuba City
- Plumas County Flood Control and Water Conservation District

North Bay Area Contractors

- Napa County Flood Control and Water Conservation District
- Solano County Water Agency

South Bay Area Contractors

- Alameda County Flood Control and Water Conservation District, Zone 7
- Alameda County Water District
- Santa Clara Valley Water District

San Joaquin Valley Area Contractors

- Dudley Ridge Water District
- Empire West Side Irrigation District
- Kern County Water Agency
- Kings County
- Oak Flat Water District
- Tulare Lake Basin Water Storage District

Figure 3-1. State Water Project Contractors

Central Coastal Area Contractors

- San Luis Obispo County Flood Control and Water Conservation District
- Santa Barbara County Flood Control and Water Conservation District

Southern California Area Contractors

- Antelope Valley–East Kern Water Agency
- Castaic Lake Water Agency
- Coachella Valley Water District
- Crestline–Lake Arrowhead Water Agency
- Desert Water Agency
- Littlerock Creek Irrigation District
- Metropolitan Water District of Southern California
- Mojave Water Agency
- Palmdale Water District
- San Bernardino Valley Municipal Water District
- San Gabriel Valley Municipal Water District
- San Gorgonio Pass Water Agency
- Ventura County Watershed Protection District

How Water Contracts Work

Under the terms of their long-term water supply contracts with DWR, the 29 SWP contractors receive specified amounts of water from the SWP each year, called "annual allocations."

The SWP's long-term water supply contracts define the terms and conditions governing water delivery and repayment of project costs. In return for the allocated water, the SWP contractors repay principal and interest on both the bonds that initially funded construction of the SWP and the bonds that paid for additional facilities. The contractors also pay all costs, including labor and power, to maintain and operate project facilities. They also pay transportation charges based on the distance between the Delta and each contractor's water delivery point.

The contractors also contribute mitigation costs for any environmental impacts of SWP operations on fish and wildlife.

"Table A" Water

Table A is an exhibit to the SWP's water supply contracts. This section explains Table A water and outlines the primary factors that influence the amount of such water actually delivered to SWP contractors.

What Is Table A Water?

The water supply–related costs of the SWP are paid for by SWP contractors. All water contracts signed in the 1960s included an estimate of the date that SWP water would first be delivered and a schedule of the amount of water the contractor could expect to be delivered annually. That amount of water, known as the contractor's annual Table A amount, was designed to increase gradually until the designated maximum for that SWP contractor was reached.

The total combined maximum Table A amount for all SWP contractors was initially 4,230 thousand acre-feet per year (taf/year), assuming full development of the SWP. At that time, this amount was referred to as the "maximum project yield." As a result of amendments to the water supply contracts in the 1990s, the current combined maximum Table A amount is 4,172 taf/year. Of this amount, 4,133 taf/year is the maximum Table A water available for delivery from the Delta. It is recognized that deliveries will be less than the established maximum Table A amount in some years and more than this amount in other years.

The maximum Table A amount is the basis for apportioning water supply and costs to the SWP contractors. Once the total amount of water to be delivered is determined for the year, all available water is allocated in proportion to each contractor's annual maximum SWP Table A amount. To reiterate, however, in some years the SWP cannot deliver the maximum amount of 4,172 taf, but in other years, project supply exceeds that amount. Additionally, in some years contractors receive other classifications of water from the SWP, such as Article 21 water and turnback pool water. (See "Other Types of SWP Water" later in this chapter.)

The established maximum Table A amounts for the 29 SWP contractors vary widely (Table 3-1). The median is 42 taf; thus, the maximum allocations of Table A water for half of the SWP contractors exceed this amount, and for the other half they are less. As shown in Table 3-1, the largest Table A amount is held by the Metropolitan Water District of Southern California at 1,911,500 acre-feet; the smallest is held by the Littlerock Creek Irrigation District at 2,300 acre-feet.

The Table A amounts determine the maximum water a contractor may request each year from DWR. Table A amounts may also be used as a factor to allocate other available water supplies to each contractor. "Table A" or "Table A water" represents a portion or all of the annual Table A requested by the SWP water contractors and approved for delivery by DWR, based on hydrologic conditions, current reservoir storage, and combined requests from the SWP water contractors. DWR is not always able to deliver the quantity of water requested by contractors. In these cases, and under certain conditions, a lesser amount is allocated and delivered according to the long-term water supply contracts by prorating the amount in proportion to each SWP water contractor's maximum Table A amount.

As discussed below, the water year type and the contractors' demand levels are among the factors involved in determining the amount of Table A water that will be delivered by DWR to each contractor. At various times of the year, DWR issues projections of anticipated Table A allocations based on then-current conditions, and updates those projections as warranted. The deliveries of Table A water to each of the SWP contractors in the last 10 years are shown in Appendix A.

Factors Influencing Percentages of Table A Water Delivery Amounts

The percentage of its maximum Table A amount that an SWP contractor will receive in any given year will vary depending on a variety of factors. The discussion below presents basic questions underlying these factors, which are described in greater detail later in this report.

Winter snowpack is an important factor determining annual Table A water deliveries.

Physical Availability of Water from Precipitation and Runoff

The amount and timing of precipitation and ensuing runoff to streams are important in determining how much water will be physically available to the SWP to pump and export from the Delta. The type of precipitation matters as well, along with anticipated patterns of use and consumption of the source water by entities other than the SWP.

The answers to the following questions influence the amount of water delivered to contractors each year:

- How much rain and snow fell within the last year?
- Which parts of California received the precipitation, and how much runoff resulted?

Table 3-1. Maximum Annual SWP Table A Water Delivery Amounts for SWP Contractors

Contractor	Maximum Table A Delivery Amounts (acre-feet)
Feather River Area Contractors	
Butte County	27,500
Yuba City	9,600
Plumas County Flood Control and Water Conservation District	2,700
Subtotal	**39,800**
North Bay Area Contractors	
Napa County Flood Control and Water Conservation District	29,025
Solano County Water Agency	47,506
Subtotal	**76,531**
South Bay Area Contractors	
Alameda County Flood Control and Water Conservation District, Zone 7	80,619
Alameda County Water District	42,000
Santa Clara Valley Water District	100,000
Subtotal	**222,619**
San Joaquin Valley Area Contractors	
Dudley Ridge Water District	50,343
Empire West Side Irrigation District	2,000
Kern County Water Agency	982,730
Kings County	9,305
Oak Flat Water District	5,700
Tulare Lake Basin Water Storage District	88,922
Subtotal	**1,139,000**
Central Coastal Area Contractors	
San Luis Obispo County Flood Control and Water Conservation District	25,000
Santa Barbara County Flood Control and Water Conservation District	45,486
Subtotal	**70,486**
Southern California Area Contractors	
Antelope Valley–East Kern Water Agency	141,400
Castaic Lake Water Agency	95,200
Coachella Valley Water District	138,350
Crestline–Lake Arrowhead Water Agency	5,800
Desert Water Agency	55,750
Littlerock Creek Irrigation District	2,300
Metropolitan Water District of Southern California	1,911,500
Mojave Water Agency	82,800
Palmdale Water District	21,300
San Bernardino Valley Municipal Water District	102,600
San Gabriel Valley Municipal Water District	28,800
San Gorgonio Pass Water Agency	17,300
Ventura County Watershed Protection District	20,000
Subtotal	**2,623,100**
TOTAL TABLE A AMOUNTS	**4,171,536**

- Did rain come as a short intense storm or a long wet spell?
- Did more of the precipitation occur as snow in colder storms, or were storms warmer, resulting in more rain that produced higher peak runoff?
- Was snowmelt fast or gradual, and when did the bulk of the runoff occur?

For example, if substantial snowfall occurs late in the wet season, Sierra Nevada rivers can be full of melting snow later than usual in the year, as occurred in 2011. This allows the SWP's Delta pumping to continue at or near capacity for an extended duration, increasing the percentage of Table A water delivered. Conversely, if rain falls on snow early in the year, the resulting early snowmelt results in less water available for Delta pumping later in the year. Other factors affecting SWP delivery reliability are discussed in Chapter 4.

Local Facilities and Demands

A contractor's local diversion, storage, and conveyance facilities are important considerations in receiving water and in storing the water it receives. A contractor's water demands can also be affected by local weather patterns and water conservation measures. In some years, some contractors may rely more on water from sources such as groundwater or the Colorado River, while in other years they may rely more on the SWP.

The pattern of water demand on a water system can greatly affect the system's reliability. For example, if the demand occurs for only 3 months in summer, a water system with sufficient annual supply but insufficient water storage may not be able to reliably meet its customers' demands. If, however, the demand is distributed over the year, the system can more easily meet the demand because the need for water storage is reduced or storage could be increased.

Other Types of SWP Water

Regardless of water year type, Table A water is given first priority for delivery over other types of SWP water. Contractors have several options for what to do with the water that is allocated to them: use it, store it for later use, or transfer it to another contractor. Each long-term water contract describes several types of SWP water that are available to SWP contractors to supplement Table A water: "Article 21" water, carryover water, and turnback pool water. These other types of project water are discussed below and the related deliveries that occurred in each of the last 10 years are shown in Appendix A.

Article 21 Water

Article 21 water (so named because it is described in Article 21 of the water contracts) is water that SWP contractors may receive on a short-term basis in addition to their Table A water, if they request it. Because most SWP contactors often cannot meet their full demands with Table A water, Article 21 water should not be viewed as "surplus" or "extra" water. In fact, Article 21 water is used by many SWP contractors to help meet demands when allocations are less than 100%. Article 21 water is available to an SWP contractor only if the following conditions are met:

- "Excess water" is flowing through the Delta—that is, when releases from SWP and CVP reservoirs and unregulated flows into the Delta exceed Sacramento Valley water diversions, Delta exports, and flows needed to meet Delta water quality and flow requirements. If this scenario occurs, it is usually during December through May.
- The contractor is able to use the surplus water, such as by offsetting the use of groundwater that would otherwise occur, or can store it in its own system. (That is, the water will not be stored in an SWP facility, such as San Luis Reservoir.)

- Delivering this water would not interfere with Table A allocations, other SWP deliveries, or SWP operations.

SWP contractors requesting Article 21 water receive this water in the same proportion as their Table A water. Article 21 water becomes available only during wet months of the year, generally December through March. Unless the SWP contractor has facilities to routinely store or manage the Article 21 water it receives, such water is not likely to contribute significantly to local water supply reliability.

Carryover Water

"Carryover water" is SWP water that is allocated to an SWP contractor and approved for delivery to that contractor in a given year, but not used by the end of the year. (Note that SWP water deliveries are managed by calendar year, January 1–December 31, while hydrology is measured by water year, October 1–September 30.) This water is exported from the Banks Pumping Plant, but instead of being delivered to the contractor, it is stored in the SWP's share of San Luis Reservoir, when space is available, for the contractor to use in the following year.

Carryover water is like a water savings account that allows water managers flexibility in tough times—such as if the next year is a drought year and the contractor's allocation of SWP water is small. Carryover water was designed to encourage the most effective and beneficial use of water and to avoid obligating the contractors to use or lose the water by December 31 of each year.

With advance notice, SWP contractors can carry over water when they submit their initial request for Table A water, or within the last 3 months of the delivery year. They might do this for various reasons, such as local wet conditions or exchange and transfer arrangements. Storage for carryover water no longer becomes available to the contractors if it interferes with storage of SWP water for project needs.

Carryover water is stored in San Luis Reservoir.

Turnback Pool Water

SWP contractors may offer the portion of their allocated Table A water within the current year that exceeds their needs in a "turnback pool," where another contractor may purchase this water. DWR sets the price for water offered in turnback pools, which are established in February and March. Contractors that sell their extra Table A water in a turnback pool receive payments from contractors that buy water through the turnback pool.

Historical SWP Deliveries (2001–2010)

Please see Appendix A for tables listing annual historical deliveries from the Delta by various water classifications for each SWP contractor for 2001–2010. Similar delivery tables for years 1999–2008 are included in the 2009 Report.

Figure 3-2 shows that deliveries of SWP Table A water from the Delta for 2001–2010 range from an annual minimum of 1,049 taf to a maximum of 2,963 taf, with an average of 2,087 taf. Historical deliveries of SWP Table A water from the Delta over this 10-year period are less than the maximum of 4,133 taf/year.

Total historical SWP deliveries from the Delta, including Table A, Article 21, turnback pool, and carryover water, range from 1,236 to 3,727 taf/year, with an average of 2,524 taf/year for the period of 2001–2010 (Figure 3-3).

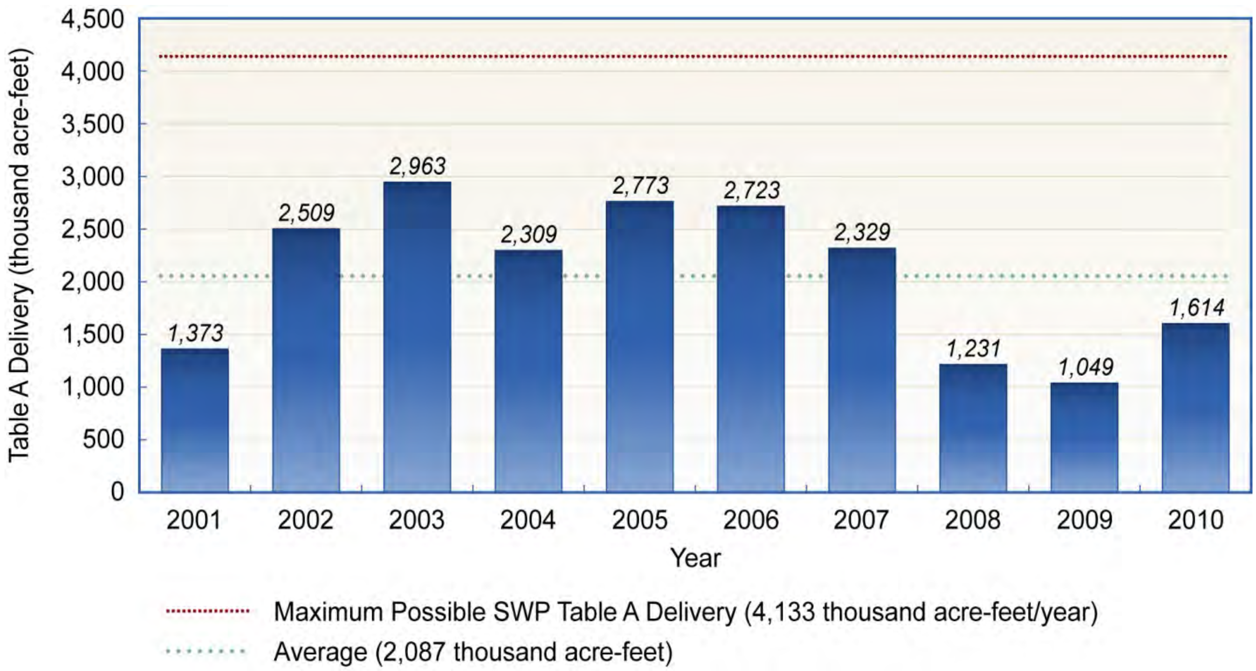
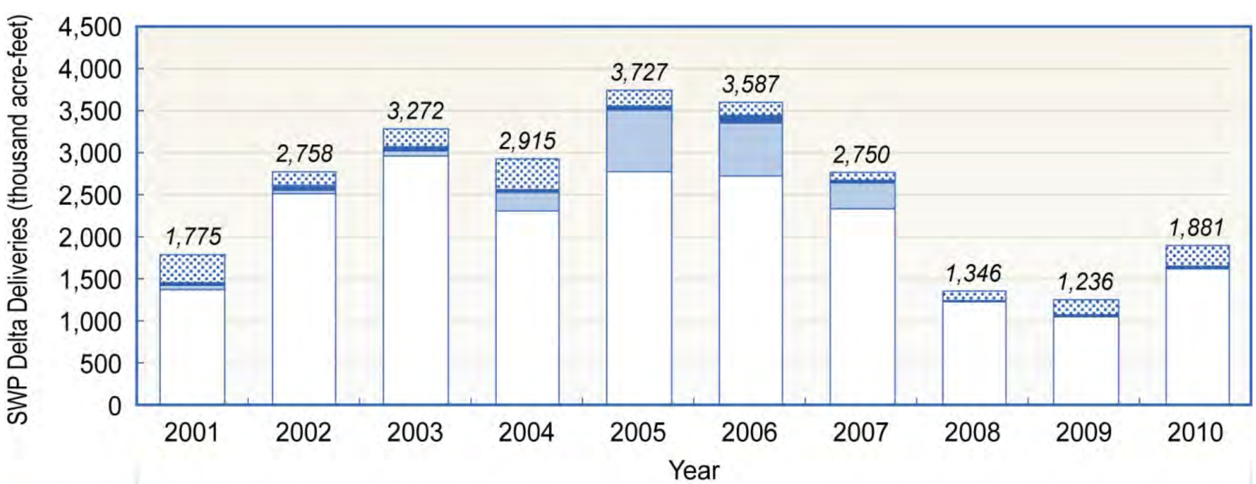


Figure 3-2. Historical Deliveries of SWP Table A Water from the Delta, 2001–2010



	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Carryover	335	161	220	370	185	160	94	110	180	248
Turnback	18	45	30	17	38	73	16	3	2	11
Article 21	48	43	60	218	731	631	310	3	6	8
Table A	1,373	2,509	2,963	2,309	2,773	2,723	2,329	1,230	1,049	1,614

Note: Due to rounding, the total delivery may not equal the sum of individual delivery type line items.

Figure 3-3. Total Historical SWP Deliveries from the Delta, 2001–2010 (by Delivery Type)

Chapter 4

Factors that Affect Water Delivery Reliability

This chapter explains the concept of SWP water delivery reliability and how it is calculated by DWR. Some of the factors that influence the percentages of SWP Table A deliveries were introduced in Chapter 3, "SWP Contractors and Water Contracts." This chapter builds on that discussion, describing the most important factors that combine to affect SWP water delivery reliability. Among these natural and human-created factors are the availability of source water, regulatory restrictions on SWP operations, and the effects of climate change.

Uncertainty also exists because of the potential for an emergency such as an earthquake striking in or near the Delta, which, if substantial enough, could interrupt SWP exports from the Delta. This chapter describes various statewide efforts by DWR and other agencies to reduce risks to the Delta and enhance emergency response capabilities.

What Water Delivery Reliability Means to SWP Contractors

Water delivery reliability is the annual amount of SWP water that can be expected to be delivered to SWP contractors with a certain frequency. But what does that actually mean in practice?

In essence, it is a matter of probability—specifically, the likelihood that a contractor will receive a certain amount of water from the SWP in a particular year. From the contractor's perspective, water delivery reliability indicates an acceptable or desirable level of dependability of water deliveries to the people receiving the water. This information is vitally important to SWP contractors for their long-term water planning and operations. Will farmers have the amount of water they will need to plant permanent crops? Will urban and suburban water districts have sufficient water to serve planned development, or will they need to call for greater conservation measures by residents and businesses? These are examples of critical questions to which SWP contractors must have answers to serve their customers.

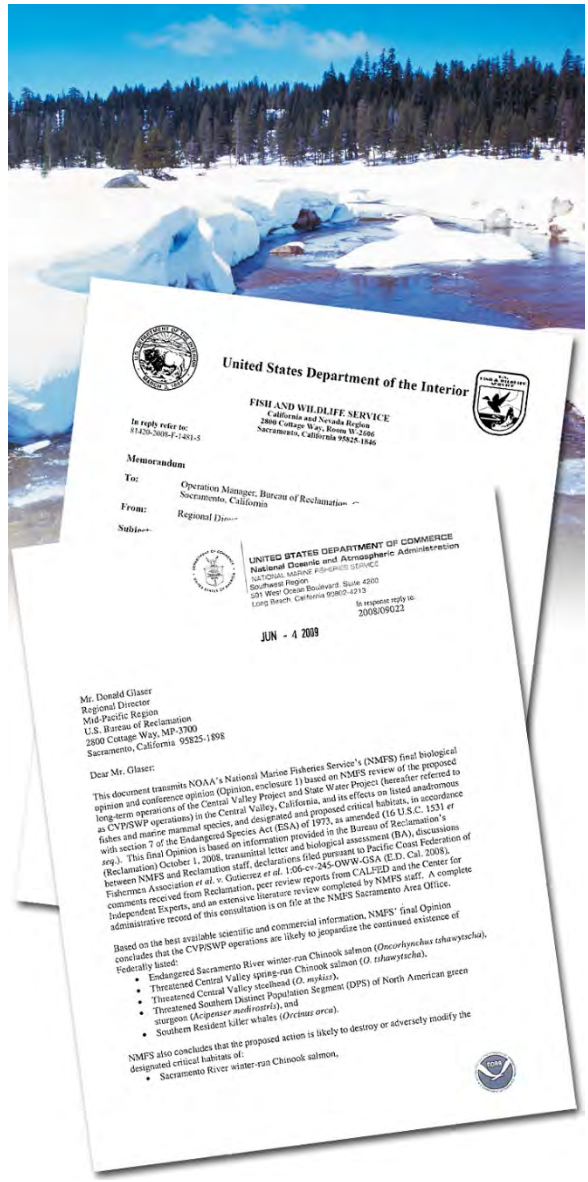
Usually, a local water agency, in coordination with the public it serves, determines the level of water delivery reliability that it considers acceptable. The water agency then plans for new facilities, programs, or additional sources of water to meet or maintain this level of reliability.

Calculating SWP Water Delivery Reliability

DWR calculates the water delivery reliability of the SWP using the CalSim-II computer model, which simulates existing and future operations of the SWP. No model or tool can predict what actual, natural water supplies will be for any year or years, but a system of probability can be used to calculate water delivery reliability. The analyses of SWP delivery reliability contained in Chapters 6 and 7 of this report are based on modeling conducted using 82 years of historical data (water years 1922–2003) for rainfall and runoff. Those data were adjusted to reflect current and future levels of development in the source areas. The resulting data were then used to forecast the amount of water available to the SWP under current and future conditions (with the effects of climate change factored into the modeling for future conditions). The annual amounts of estimated SWP water deliveries are ranked from smallest to largest and the probability that various quantities of SWP Table A water will be delivered to each SWP contractor is estimated.

Factors that Can Influence the SWP's Water Delivery Reliability

Forecasting water delivery reliability is a difficult task because California is such a large state with numerous microclimates. In a typical year, some areas receive as little as 2 inches of rain, while others receive more than 100 inches. In addition, the determinants of water delivery for a specific water supply system continually change over time and can be difficult to determine and/or model. For example, water use in Sacramento River watersheds has increased over time. The historical data upon which a water supply forecast is based must be adjusted to reflect the current and, if necessary, future use in these watersheds.



Natural factors such as snowmelt and human influences such as federal biological opinions can both influence the SWP's water delivery reliability.

The following factors affect the ability to estimate existing and especially future water delivery reliability:

- water availability at the source,
- water rights with priority over the SWP,
- regulatory restrictions on SWP Delta exports (imposed by federal biological opinions [BOs] and State water quality plans),
- climate change,

- ongoing environmental and policy planning efforts, and
- Delta levee failure.

Water Availability at the Source

This factor affects the SWP's water delivery reliability because it is inherently variable; availability of water at the source depends on the amount and timing of rain and snow that fall in any given year, the amount and timing of runoff, and the level of development (that is, the use of water) in the SWP's source areas. The location, amount, and form of precipitation in California in any given year cannot be accurately predicted, introducing the greatest uncertainty to the availability of future SWP source water and hence future SWP deliveries.

Generally, during a single dry year or two, surface water and groundwater storage can supply most water deliveries, but dry years can result in critically low water reserves.

DWR measures the water content of snowpack in the northern Sierra Nevada to forecast snowmelt runoff.

Greater reliance on groundwater during dry years results in high costs for many users and increases groundwater overdraft. Further, the ability of some contractors to use local groundwater may be limited; some groundwater basins may be contaminated by toxins such as methyl tertiary butyl ether (commonly known as MBTE), an ingredient in gasoline, and other aquifers may be too deep to reach economically. This makes the availability of the SWP's surface water to contractors especially important.

DWR manually measures snowpack in the northern Sierra Nevada monthly between early January and early May to forecast snowmelt runoff. These surveys and real-time electronic measurements taken throughout the winter measure the snowpack's water content. The size of the snowpack in the Feather River watershed on April 1—when snowpack water content normally is at its peak before the spring runoff—and the storage in Lake Oroville are key components of the SWP's delivery capabilities from April through September.

However, in some years, even measurements taken in the northern Sierra Nevada earlier in the year can demonstrate an apparent trend in water delivery reliability for the rest of the year (assuming that the weather follows typical patterns in spring). For example, manual readings conducted by DWR on December 28, 2010, off U.S. Highway 50 near Echo Summit showed snow-water equivalents in the state's northern mountains at 169% of normal for that date and 57% of the normal value for April 1. By contrast, the readings taken on the same date in 2009 had indicated snow-water equivalents in the northern mountains at 77% of normal for the date and 26% of the normal value for April 1. These findings indicated the potential for SWP deliveries in 2011 to increase relative to deliveries that occurred in 2010, a below-normal water year.

Water Rights with Priority Over the SWP

California's water rights system affects the SWP indirectly. There are two types of legally protected rights to surface water in California:

- *Appropriative* water rights allow the user to divert surface water for beneficial use. The user must first have obtained a permit from the State Water Resources Control Board (State Water Board), unless the appropriative water right predates 1914. Appropriative water rights may be lost if the water has gone unused for 5 years. The SWP diverts water from the Delta under appropriative water rights.
- *Riparian* water rights apply to lands traversed by or bordering on a natural watercourse. No permit is required to use this water, which must be used on riparian (adjacent) land and cannot be stored for later use.

Generally, the priority of an appropriative water right in California is "first in time, first in right"; therefore, an appropriative water right is subordinate to all prior water rights, whether appropriative or riparian. This means that if another entity with a prior water right increases its use of one of the SWP's sources of water supply—the Delta, the upstream Sacramento or San Joaquin River, or a tributary to either river—the overall amount of water available to the SWP will decrease. Thus, water users with prior water rights are assigned top priority for water in DWR's modeling of the SWP's water delivery reliability, even ahead of SWP Table A water deliveries.

Regulatory Restrictions on SWP Delta Exports

Multiple needs converge in the Delta: the need to protect a fragile ecosystem, to support Delta recreation and farming, and to provide water for agricultural and urban needs throughout much of California. Various regulatory requirements are placed on the SWP's Delta operations to protect special-status species such as delta smelt and spring- and winter-run Chinook salmon. As a result, as described below, restrictions on SWP operations imposed by State and federal agencies contribute substantially to the challenge of accurately determining the SWP's water delivery reliability in any given year.

Biological Opinions on Effects of Coordinated SWP and CVP Operations

Several fish species listed under the federal Endangered Species Act (ESA) as endangered or threatened are found in the Delta. The continued viability of populations of these species in the Delta depends in part on Delta flow levels. For this reason, the U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) have issued several BOs since the 1990s on the effects of coordinated SWP/CVP operations on several species.

These BOs affect the SWP's water delivery reliability for two reasons. Most obviously, they include terms that specifically restrict SWP pumping levels in the Delta at certain times under certain conditions. In addition, the BOs' requirements are based on physical and biological phenomena that occur daily while DWR's water supply models are based on monthly data.

The first BOs on the effects of SWP (and CVP) operations were issued in February 1993 (NMFS BO on effects of project operations on winter-run Chinook salmon) and March 1995 (USFWS BO on project effects on delta smelt and splittail). Among other things, the BOs contained requirements for Delta inflow, Delta outflow, and reduced export pumping to meet specified incidental take limits. These fish protection requirements imposed substantial constraints on Delta water supply operations. Many were incorporated into the 1995 *Water Quality Control Plan for the San Francisco Bay/Sacramento–San Joaquin Delta* (1995 WQCP), as described in the "Water Quality Objectives" section later in this chapter.

The terms of the USFWS and NMFS BOs have become increasingly restrictive in recent years. In December 2008, USFWS issued a new BO covering effects of the SWP and CVP on delta smelt, and in June 2009, NMFS issued a BO covering effects on winter-run and spring-run Chinook salmon, steelhead, green sturgeon, and killer whales. These BOs replaced BOs issued earlier by the federal agencies.

The USFWS BO includes additional requirements in all but 2 months of the year. The BO calls for "adaptively managed" (adjusted as necessary based on the results of monitoring) flow restrictions in the Delta intended to protect delta smelt at various life stages. USFWS determines the required target flow, with the reductions accomplished primarily by reducing SWP and CVP exports. Because this flow restriction is determined based on fish location and decisions by USFWS staff, predicting the flow restriction and corresponding effects on export pumping with any great certainty poses a challenge. The USFWS BO also includes an additional salinity requirement in the Delta for September and October in wet and above-normal water years, calling for increased releases from SWP and CVP reservoirs to reduce salinity. Among other provisions included in the NMFS BO, limits on total Delta exports have been established for the months of April and May. These limits are mandated for all but extremely wet years.

The 2008 and 2009 BOs were issued shortly before and shortly after the Governor proclaimed a statewide water shortage state of emergency in February 2009, amid the threat of a third consecutive dry year. NMFS calculated that implementing its BO would reduce SWP and CVP Delta exports by a combined 5% to 7%, but DWR's initial estimates showed an impact on exports closer to 10% in average years, combined with the effects of pumping restrictions imposed by BOs to protect delta smelt and other species. The 2008 USFWS and 2009 NMFS BOs have been subject to considerable litigation. Recent decisions by U.S. District Judge Oliver Wanger changed specific operational rules for the fall/winter of 2011–2012, and both the USFWS BO and NMFS BO have been remanded to the agencies for further review and analysis. However, the operational rules specified in the 2008 and 2009 BOs continue to be legally required and are the rules used in the analyses presented in Chapters 5, 6, and 7 of this report. Chapter 5 presents a comparison of monthly Delta exports as estimated for this 2011 Report with those estimated for the 2005 Report, illustrating how the 2008 and 2009 BOs have affected export levels from the Delta.

The California Department of Fish and Game (DFG) issued consistency determinations for both BOs under Section 2080.1 of the California Fish and Game Code. The consistency determinations stated that the USFWS BO and the NMFS BO would be consistent with the California Endangered Species Act (CESA). Thus, DFG allowed incidental take of species listed under both the federal ESA and CESA to occur during SWP and CVP operations without requiring DWR or the U.S. Bureau of Reclamation to obtain a separate State-issued permit.

Specific restrictions on Delta exports associated with the USFWS and NMFS BOs and their effects on SWP pumping levels are described further in Chapter 5, "SWP Delta Exports," of this report.

Water Quality Objectives

Because the Delta is an estuary, salinity is a particular concern. In the 1995 WQCP, the State Water Board set water quality objectives to protect beneficial uses of water in the Delta and Suisun Bay. The objectives must be met by the SWP (and federal CVP), as specified in the water right permits issued to DWR and the U.S. Bureau of Reclamation. Those objectives—minimum Delta outflows, limits on SWP and CVP Delta exports, and maximum allowable salinity levels—are enforced through the provisions of the State Water Board's Water Right Decision 1641 (D-1641), issued in December 1999 and updated in March 2000.

DWR and Reclamation must monitor the effects of diversions and SWP and CVP operations to ensure compliance with existing water quality standards. Monitoring stations are shown in Figure 4-1.

Among the objectives established in the 1995 WQCP and D-1641 are the "X2" objectives. D-1641 mandates the X2 objectives so that the State Water Board can regulate the locations of the Delta estuary's salinity gradient during the months of February–June. X2 is the position in the Delta where the electrical conductivity (EC) level, or salinity, of Delta water is 2 parts per thousand. The location of X2 is used as a surrogate measure of Delta ecosystem health. For the X2 objective to be achieved, the X2 position must remain downstream of Collinsville in the Delta (shown in Figure 4-1) for the entire 5-month period, and downstream of other specific locations in the Delta on a certain number of days each month from February through June. This means that Delta outflow must be at certain specified levels at certain times—which can limit the amount of water the SWP may pump at those times at its Harvey O. Banks Pumping Plant in the Delta. Because of the relationship between seawater intrusion and interior-Delta water quality, meeting the X2 objective also improves water quality at Delta drinking-water intakes; however, meeting the X2 objectives can require a relatively large volume of water for outflow during dry months that follow months with large storms.

The 1995 WQCP and D-1641 also established an export/inflow (E/I) ratio. The E/I ratio, presented in Table 3 of the 1995 WQCP (SWRCB 1995:18–22), is designed to provide protection for the fish and wildlife beneficial uses in the Bay-Delta estuary (SWRCB 1995:15). The E/I ratio limits the fraction of Delta inflows that are exported. When other restrictions are not controlling, Delta exports are limited to 35% of total Delta inflow from February through June and 65% of inflow from July through January.

Climate Change

The *California Water Plan Update 2009* identified climate change as a key consideration in planning for the State's water management. California's reservoirs and water delivery systems were developed based on historical hydrology; future weather patterns have long been assumed to be similar to those in the past. However, as climate change continues to affect California, past hydrology is no longer a reliable guide to future conditions. This section discusses effects on the SWP that could result from specific aspects of climate change.

Decreased Water Availability with Reduced Snowpack

As the effects of climate change continue, mean temperatures are predicted to increase, both globally and regionally. Climate projections used to assess the reliability of California's future water supply forecast average air temperature increases for the Sacramento region of 1.3 to 4.0 degrees Fahrenheit by the middle of the 21st century and 2.7 to 8.1 degrees by the end of the century (California Climate Change Center 2009a:8). Climate change is anticipated to bring warmer storms that result in less snowfall at lower elevations, reducing total snowpack. Loss of snowpack is projected to be greater in the northern Sierra Nevada—and thus closer to the Feather River watershed, the origin of SWP water—than in the southern Sierra Nevada because of the relative proportions of land at low and middle elevations.

Snowmelt provides an average of 15 million acre-feet of water for California per year, slowly released from about April to July each year (DWR 2006:2-22). Much of the state's water infrastructure, including the SWP, was designed to capture slow spring runoff and deliver it during the drier summer and fall months. However, during the 20th century, the average early-spring

Figure 4-1. Delta Salinity Monitoring Locations of Importance to the SWP

snowpack in the Sierra Nevada decreased by about 10%, resulting in the loss of 1.5 million acre-feet of snowpack storage (DWR 2008:3). Using historical data and modeling, DWR projects that by 2050 the Sierra snowpack will be reduced from its historical average by 25% to 40% (DWR 2008:4). Increased precipitation falling as rain instead of snow during winter could result in a larger number of "rain-on-snow" events. This would cause the snow to melt earlier in the year and over fewer days than historically, thus adversely affecting availability of water for pumping by the SWP during summer.

Such reductions in snowpack could have dire consequences. Under climate change and in some years, water levels in Lake Oroville, the SWP's main supply reservoir, could fall below the lowest release outlets, making the system vulnerable to operational interruption. DWR expects that a water shortage worse than the one during the 1977 drought could occur in 1 out of every 6–8 years by the middle of the 21st century and in 1 out of every 3–4 years at the end of the century (California Climate Change Center 2009a:46). In those years, it is estimated that an additional 575,000–850,000 acre-feet per year of water would be needed to meet current regulatory requirements and to maintain minimum system operations. This could preclude the SWP from pumping as much water as it would otherwise.

Climate change is also expected to reduce the SWP's median reservoir carryover storage. Carryover water is like a water savings account for water managers to use during shortage periods. Thus, a climate change–generated reduction in the amount of carryover water available to SWP contractors would reduce the system's flexibility during dry and critical water years.

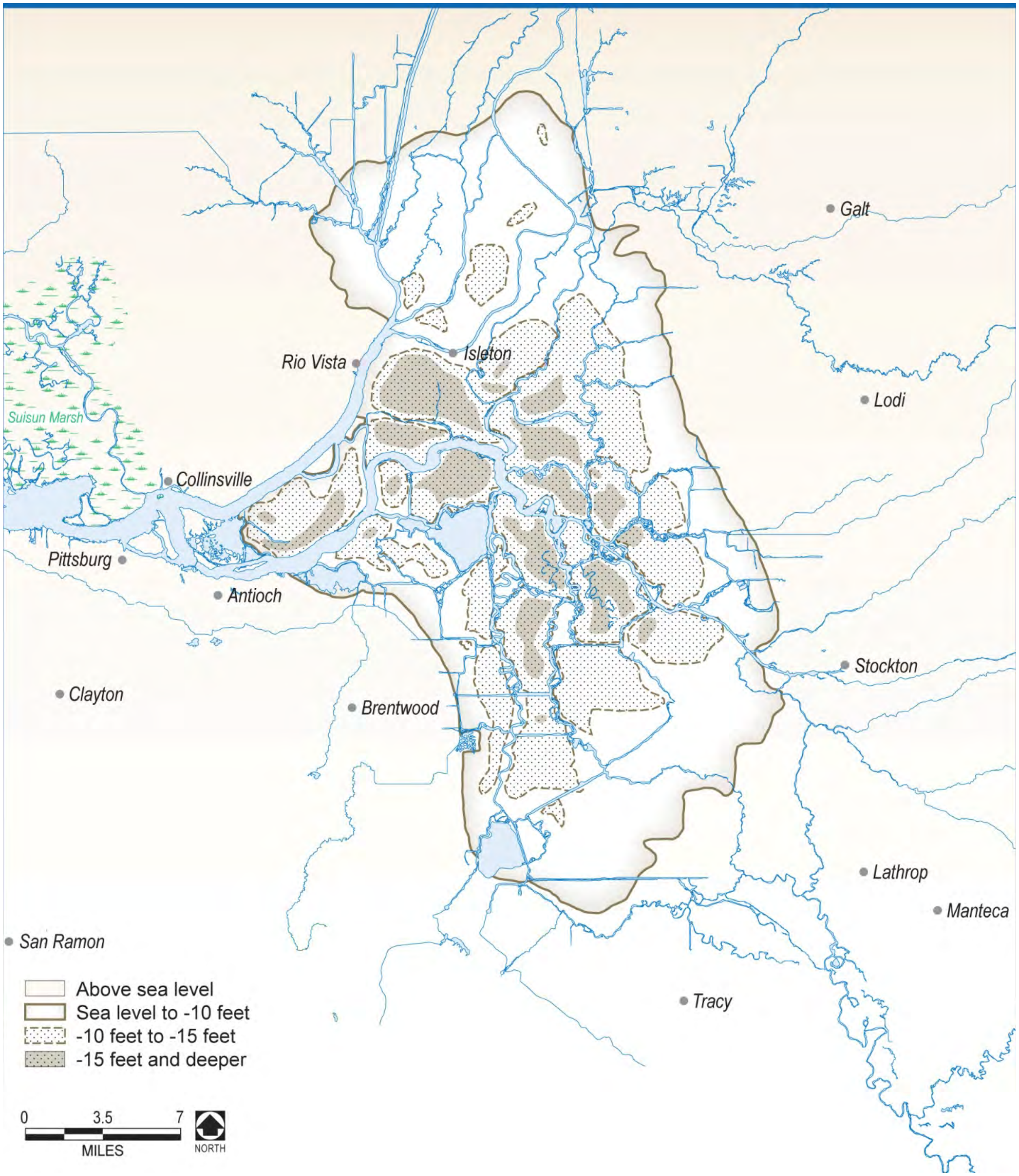
Increased SWP Water Demands

Even as water shortages may result from reduced snowpack, climate change may also cause water demand by SWP contractors to increase. Warmer temperatures may increase rates of evapotranspiration (loss of water from soil by evaporation and plant transpiration) and may extend growing seasons. A larger amount of water may be needed for irrigation of certain crops, urban landscaping, and environmental needs. Warmer temperatures will also increase evaporation from surface reservoirs. Reduced soil moisture and surface flow will disproportionately affect the environment and other water users that rely heavily on annual rainfall such as rainfed agriculture, livestock grazing on nonirrigated rangeland, and recreation.

Sea Level Rise

During the last century, sea level rose 7 inches along California's coast. Estimates of future sea level rise range from 4 to 16 inches by the middle of the 21st century and 7–55 inches by 2100 (DWR 2009b:4-37). The increases in sea level that are expected to continue could affect SWP water delivery reliability in several ways:

- Most of the land in the Delta is below sea level—by as much as 20 feet—as a consequence of ongoing subsidence (Figure 4-2). Increases in sea level could place more pressure on the Delta's already fragile levee system and, as a consequence, cause levee breaches that could threaten SWP Delta exports.
- As salty water from the Pacific Ocean moves farther upstream into the Delta, DWR could be required to increase the amounts of freshwater released from Lake Oroville to maintain compliance with Delta water quality standards.
- Sea level rise is expected to cause salt water to flow farther inland. The resulting increase in saltwater intrusion into coastal aquifers would make increasing amounts of groundwater unsuitable for water supply or irrigation (California Climate Change Center 2009b:80–81). The reduced availability of groundwater would likely contribute to further increases in demands for surface water from the SWP, especially by the coastal SWP contractors.



Source: DWR 1995:28

Figure 4-2. Areas of the Delta that Have Subsided to Below Sea Level

Adapting to Climate Change Effects in Forecasting Water Delivery Reliability

Chapter 7, "Future SWP Water Delivery Reliability (2031)," of this report estimates the SWP's delivery reliability for conditions 20 years in the future (2031), reflecting potential hydrologic changes that could result from climate change. Further details on these future projections are included in a technical addendum to this report (posted on the Internet and available upon request).

For purposes of this report and the technical addendum, the 2031 delivery estimates are based on a single median-impact future climate projection. To identify this projection, DWR analyzed the 12 climate projections for midcentury that were used in *Using Future Climate Projections to Support Water Resources Decision Making in California* (California Climate Change Center 2009a). The resulting water supply effects were examined to determine which one most closely represented the "central" or "median" projection. The analysis examined the following projected climate and hydrology variables and their effects on SWP exports: temperature, precipitation, total inflow to major reservoirs, shifts in timing of runoff, and Delta exports.

Ongoing Environmental and Policy Planning Efforts

As discussed earlier, the Delta is an essential part of the conveyance system for the SWP. SWP pumping at the Banks Pumping Plant is regulated to protect the many uses of the Delta. However, today's uses in the Delta are not sustainable over the long term under current management practices and regulatory requirements. As discussed below, two large-scale plans for the Delta that are in development could affect SWP water delivery reliability: the Delta Plan and the Bay Delta Conservation Plan (BDCP).

Delta Plan

After years of concern about the Delta amid rising water demand and habitat degradation, the Delta Stewardship Council was created in legislation to achieve State-mandated coequal goals for the Delta. As specified in Section 85054 of the California Water Code:

> "Coequal goals" means the two goals of providing a more reliable water supply for California and protecting, restoring, and enhancing the Delta ecosystem. The coequal goals shall be achieved in a manner that protects and enhances the unique cultural, recreational, natural resource, and agricultural values of the Delta as an evolving place.

The draft Delta Plan seeks to reduce reliance on Delta water supplies. In a series of policies and recommendations, the draft plan aims to encourage farms and cities to increase conservation and become more self-sufficient, particularly in the event of a disaster in the Delta. It calls for agricultural water agencies to change pricing to encourage conservation. It also urges the State Water Board to set enforceable flow objectives for the Delta and its tributaries that take into account wildlife and habitat needs. In the future, government projects in the Delta must prove they are consistent with the Delta Plan.

The Delta Stewardship Council is preparing the draft Delta Plan and environmental impact report. Scheduled for adoption and implementation in 2012, the Delta Plan is intended to serve as California's guiding policy document for the Delta and Suisun Marsh for the next 88 years (that is, through the year 2099), with frequent updates.

Bay Delta Conservation Plan

The BDCP is being prepared by a group of local water agencies, environmental and conservation organizations, State and federal agencies, and other interest groups. An outgrowth of the CALFED Bay-Delta Plan's Ecosystem Restoration Program Conservation Strategy, the BDCP has been in development since 2006. The heart of the BDCP is a long-term conservation strategy that sets forth actions needed for a healthy Delta. The BDCP would do all of the following:

- identify conservation strategies to improve the overall ecological health of the Delta;
- identify ecologically friendly ways to move freshwater through and/or around the Delta;
- address toxic pollutants, invasive species, and impairments to water quality; and
- establish a framework and funding to implement the plan over time.

A draft environmental impact report is planned to be released for public review in mid-2012. The report is targeted to be final in 2013, after which a decision to proceed with the program would be made. Upon adoption, the BDCP would provide the basis for issuance of endangered species permits for the continued operation of the SWP and CVP. The plan would be implemented over a 50-year period.

Delta Levee Failure

The fragile Delta faces a multitude of risks that could affect millions of Californians. Foremost among those risks, as they could affect the SWP's water delivery reliability, are the potential for levee failure and the ensuing flooding and water quality issues.

The Delta Risk Management Strategy (DRMS) was initiated in response to Assembly Bill 1200 (2005), which directed DWR to use 50-, 100-, and 200-year projections to evaluate the potential impacts on Delta water supplies associated with continued land subsidence, earthquakes, floods, and climate change. The discussions below describe DRMS Phase 1, which evaluated the risks, and DRMS Phase 2, which is proposing various solutions. Also discussed are other efforts currently being undertaken by DWR and other agencies to reduce risks to the Delta, enhance emergency response capabilities, and reduce the risk of interruption of Delta water exports by the SWP and CVP.

Effects of Emergencies on Water Supplies: Delta Risk Management Strategy, Phase 1

Phase 1 of the DRMS, completed in 2008, assessed the performance of Delta and Suisun Marsh levees under various stressors and hazards and evaluated the consequences of levee failures to California as a whole.

The Delta is protected by levees built about 150 years ago. The levees are vulnerable to failure because most original levees were simply built with soils dredged from nearby channels, and were never engineered. Most islands in the Delta have flooded at least once over the past 100 years. For example, on June 3, 2004, a huge dry-weather levee failure occurred without warning on Upper Jones Tract in the south Delta, inundating 12,000 acres of farmland with about 160,000 acre-feet of water. Because many Delta islands are below sea level, deep and prolonged flooding could occur during a levee failure event, which could disrupt the quality and use of Delta water.

Levee failure can result from the combination of high river inflows, high tide, and high winds; however, levees can also fail in fair weather—even in the absence of a flood or seismic event—in a so-called "sunny day event." Damage caused by rodents, piping (in which a pipe-like opening develops below the base of the levee), or foundation movement could cause sunny-day levee breaches.

Many vulnerable Delta levees require installation of rock revetments, riprap, or other engineered structures along eroding banks to reduce erosion and protect levee foundations.

A breach of one or more levees and island flooding may affect Delta water quality and SWP operations. Depending on the hydrology and the size and locations of the breaches and flooded islands, a large amount of salt water may be pulled into the interior Delta from Suisun and San Pablo Bays. When islands are flooded, DWR may need to drastically decrease or even cease SWP Delta exports to evaluate the distribution of salinity in the Delta and avoid drawing saltier water toward the pumps.

Delta levees are prone to failure, increasing risks to State water supplies.

An earthquake could also put Delta levees, and thus SWP water supplies, at risk. In 2008, the 2007 Working Group on California Earthquake Probabilities estimated a probability of 63% that a magnitude 6.7 or greater earthquake would strike the San Francisco Bay Area in the next 30 years (Working Group 2008:6). An earthquake could severely damage Delta levees, causing islands to flood with salty water. The locations most likely to be affected by an earthquake are the west and southwest portions of the Delta because these areas are closer to potential earthquake sources. Flooding of the west and southwest Delta is also more likely to interfere with conveyance of freshwater to export pumps (DWR 2007:17).

Modeling of the effects of earthquakes on Delta islands was conducted by DWR for the DRMS Phase 1 report. Described in the *California Water Plan Update 2009*, the assessment found a 40% probability that a major earthquake occurring between 2030 and 2050 would cause 27 or more islands to flood at the same time. If 20 islands were flooded as a result of a major earthquake, the export of freshwater from the Delta could be interrupted by about a year and a half (DWR 2009b:5-15). Water supply losses of up to 8 million acre-feet would be incurred by SWP (and CVP) contractors and local water districts.

Managing and Reducing Risks: Delta Risk Management Strategy, Phase 2

The Phase 2 report for the DRMS, issued in June 2011, evaluates alternatives to reduce the risk to the Delta and the state from adverse consequences of levee failure (DWR 2011b). "Building blocks" (individual improvements or projects, such as improving levees or raising highways) and trial scenarios (various combinations of building blocks) were developed for the DRMS Phase 2 report. The building blocks fall into three main categories:

- conveyance improvements/ flood risk reduction and life safety,
- infrastructure risk reduction, and
- environmental risk mitigation.

The first of these categories is most relevant to the SWP in terms of reducing the risk of disruption of SWP Delta exports, but the environmental risk mitigation category includes a building block (Building Block 3.6) calling for reduction of water exports from the Delta.

Four trial scenarios were developed to represent a range of possible risk reduction strategies:

- *Trial Scenario 1—Improved Levees:* Improve the reliability of Delta levees against flood-induced failures by providing up to 100-year flood protection.
- *Trial Scenario 2—Armored Pathway (Through-Delta Conveyance):* Improve the reliability of water conveyance by creating a route through the Delta that has high reliability and the ability to minimize saltwater intrusion into the south Delta.
- *Trial Scenario 3—Isolated Conveyance Facility:* Provide high reliability for conveyance of export water by building an isolated conveyance facility on the east side of the Delta.
- *Trial Scenario 4—Dual Conveyance:* Improve reliability and flexibility for conveyance of export water by constructing an isolated conveyance facility and a through-Delta conveyance. (This scenario would be much like a combination of Trial Scenarios 2 and 3.)

The findings of the DRMS Phase 2 report on these scenarios, as they apply to seismic risk and potential for disruption of SWP Delta exports, are as follows:

- Trial Scenario 1 (Improved Levees) would not reduce the risk of potential water export interruptions, nor would it change the seismic risk of most levees.
- Trial Scenario 2 (Armored Pathway [Through-Delta Conveyance]) would have the joint benefit of reducing the likelihood of levee failures from flood events and earthquakes and of significantly reducing the likelihood of export disruptions.
- The effects of Trial Scenario 3 (Isolated Conveyance) would be similar to those for the Armored Pathway scenario, but Trial Scenario 3 would not reduce the seismic risk of levee failure on islands that are not part of the isolated conveyance facility.
- Trial Scenario 4 (Dual Conveyance) would avoid the vulnerability of water exports associated with Delta levee vulnerability and would offer flexibility in water exports from the Delta and/or the isolated conveyance facility. However, seismic risk would not be reduced on islands not part of the export conveyance system or infrastructure pathway.

As noted in the discussion of the "enhanced emergency preparedness/response" building block in the DRMS Phase 2 report, analyses on resuming water exports after a levee failure were conducted by the Metropolitan Water District of Southern California, an SWP contractor. The studies found that a promising way to resume water exports would be to place structural barriers at selected channel locations in the Delta and complete strategic levee repairs, thus isolating an emergency freshwater conveyance "pathway" through channels that may be surrounded by islands flooded with saline water (Moffatt and Nichol 2007, cited in DWR 2011b:5-1).

Delta Flood Emergency Preparedness, Response, and Recovery Program and Delta Multi-Hazard Coordination Task Force

In the last 5 years, DWR has worked to improve its ability to respond quickly and effectively to simultaneous levee failures on multiple islands within the Delta. The *Delta Emergency Operations Plan Concept Paper* released in April 2007 (DWR 2007) was the initial product of this effort. To enhance the State's ability to prepare for, respond to, and recover from a catastrophic Delta levee failure, DWR subsequently began development of the Delta Flood Emergency Preparedness, Response, and Recovery Program. This program is intended to supplement DWR's emergency operations plan. The goal is to protect lives, property, and critical infrastructure in the Delta while minimizing impacts on the ecosystem. The program consists of three components:

- develop DWR's Delta response and recovery plan,
- coordinate DWR's plan with other Delta flood emergency response agencies, and

- design and implement flood emergency response facilities within the Delta.

The flood emergency response plan for the Delta will describe the actions DWR will take before, during, and after a levee-endangering event or levee failure in the Delta. The Delta Flood Emergency Preparedness, Response, and Recovery Program is conducting an extensive effort to model water quality implications of levee failure and salinity changes associated with different levee repair strategies. DWR is coordinating this effort with the U.S. Army Corps of Engineers and expects to reach out to the five Delta counties during plan development.

DWR is also a member of the Sacramento–San Joaquin Delta Multi-Hazard Coordination Task Force, which was created in 2008 in the wake of passage of the Sacramento–San Joaquin Delta Emergency Preparedness Act of 2008. The task force is led by the California Emergency Management Agency (CalEMA); in addition to DWR, the Delta Protection Commission and representatives from each of the five Delta counties also participate in task force activities. An Emergency Preparedness and Response White Paper was prepared for the Delta Stewardship Council on November 8, 2010, describing the operations of this task force.

The Sacramento–San Joaquin Delta Multi-Hazard Coordination Task Force was created to make recommendations to CalEMA on creating a framework for an interagency unified command system, coordinate the development of a draft emergency preparedness and response strategy for the Delta region, and develop and conduct an all-hazards emergency response exercise in the Delta. The task force's draft emergency preparedness and response strategy includes a process for allocating scarce resources and a statement of priorities agreed to by the members of the task force. The original deadline for the task force's report has been legislatively extended to January 1, 2013.





Chapter 5

SWP Delta Exports

The purpose of this chapter is to illustrate the effects of factors described in Chapter 4, "Factors that Affect Water Delivery Reliability," on SWP water supplies transferred through the Delta and pumped at the Harvey O. Banks Pumping Plant in the south Delta. These supplies are referred to as "Delta exports." Past SWP delivery reliability reports characterized SWP deliveries in their entirety but did not focus specifically on Delta exports. This chapter describes SWP Delta exports to illustrate how regulatory requirements and climate change have affected or will affect the SWP's Delta water supplies, and to describe the general pattern of monthly SWP exports from the Delta.

This chapter focuses only on Delta exports that are associated with the SWP, not on CVP water that may have been exported through the Banks Pumping Plant via the CVP/SWP joint point of diversion.

This chapter briefly explains the difference between Delta exports and SWP deliveries, then describes trends in projected average annual exports and SWP Table A water deliveries under various recent existing-conditions scenarios. In addition, monthly exports estimated for this *State Water Project Delivery Reliability Report 2011* (2011 Report) are compared with those estimated for the *State Water Project Delivery Reliability Report 2005* (2005 Report) to illustrate the effect of regulatory restrictions.

This chapter also summarizes the primary factors influencing the SWP's Delta export operations and deliveries, presents estimates of exports for the existing-conditions and future-conditions scenarios, and characterizes the likelihood of such exports. Estimated SWP Delta exports by water year type are depicted relative to exports that were estimated for the existing-conditions and future-conditions scenarios in the *State Water Project Delivery Reliability Report 2009* (2009 Report).

SWP Delta Exports versus SWP Deliveries

SWP Delta exports and SWP deliveries are characterized in separate chapters (this chapter for Delta exports, Chapters 6 and 7 for SWP deliveries) because these two terms are not one and the same.

Water pumped from the Delta is the primary source of SWP supply for 24 of the

29 SWP water contractors listed in Chapter 3, "SWP Contractors and Water Contracts." (Occasionally, during very wet periods, flood flows can enter the aqueduct and contribute to SWP supply south of the Delta.) As used in this report, "Delta exports" are the water supplies that are transferred ("exported") directly to SWP contractors or to San Luis Reservoir storage via the Banks Pumping Plant.

SWP Delta exports do not include deliveries of SWP water to the two North Bay Area contractors, which receive SWP water pumped by the Barker Slough Pumping Plant and conveyed by the North Bay Aqueduct. (Water conveyed to the SWP's three Feather River Area contractors is not transferred through the Delta and is not the focus of this chapter or of Chapters 6 and 7.)

By contrast, SWP Table A water deliveries from the Delta include both water pumped by the Banks Pumping Plant and conveyed by the California Aqueduct and water pumped by the Barker Slough Pumping Plant and conveyed by the North Bay Aqueduct. Thus, Table A water deliveries, as described in Chapters 6 and 7, also include deliveries to the two North Bay Area contractors, for a total of 26 SWP contractors.

SWP Delta exports include nearly all types of SWP water, not merely Table A water (see the explanation of SWP water types in Chapter 3). As allowed under the SWP's water supply contracts, the amount pumped from the Delta can be exported in the same year as Table A water, or can be exported as Article 21 water if available. A contractor can opt to have exported Table A water held in San Luis Reservoir as carryover water—that is, as part of the contractor's supply for a subsequent year or made available to another SWP contractor as turnback pool water. Article 21 water must be delivered immediately to SWP contractors when exported and cannot be stored in SWP facilities.

Recent Trends in SWP Delta Exports and Table A Deliveries

SWP Delta exports and Table A deliveries estimated for this 2011 Report are reduced by the operational restrictions imposed on the SWP by the biological opinions (BOs) issued by the U.S. Fish and Wildlife Service (USFWS) in December 2008 and the National Marine Fisheries Service (NMFS) in June 2009. This same scenario occurred in the 2009 Report. By contrast, the *State Water Project Delivery Reliability Report 2007* (2007 Report) incorporated interim, less restrictive operational rules established by U.S. District Judge Oliver Wanger in December 2007 while the USFWS and NMFS BOs were rewritten. The 2005 Report was based on much less restrictive operational rules contained in the BOs that had been issued in late 2004 and 2005.

Overall trends in both SWP Delta exports and Table A deliveries under existing conditions are summarized below. (For further detail on estimated SWP Table A deliveries for the existing-conditions and future-conditions scenarios, respectively, see Chapters 6 and 7.)

Annual Exports and Table A Deliveries—2005–2011 Scenarios

Figure 5-1 illustrates the effect of the operational restrictions imposed by the USFWS and NMFS BOs on estimated average annual Delta exports and Table A water deliveries. The figure depicts the average values estimated for existing conditions in the 2005, 2007, 2009, and 2011 Reports.

As shown in Figure 5-1, estimated average annual Delta exports and SWP Table A water deliveries have generally decreased since 2005, when rules affecting SWP pumping operations began to become more restrictive. Under existing conditions, average annual Delta exports have decreased since 2005 from 2,958 thousand acre-feet per year (taf/year) to 2,607 taf/year in 2011, a decrease of 351 taf or 11.9%; average annual Table A deliveries have decreased since 2005 from 2,818 taf/year to

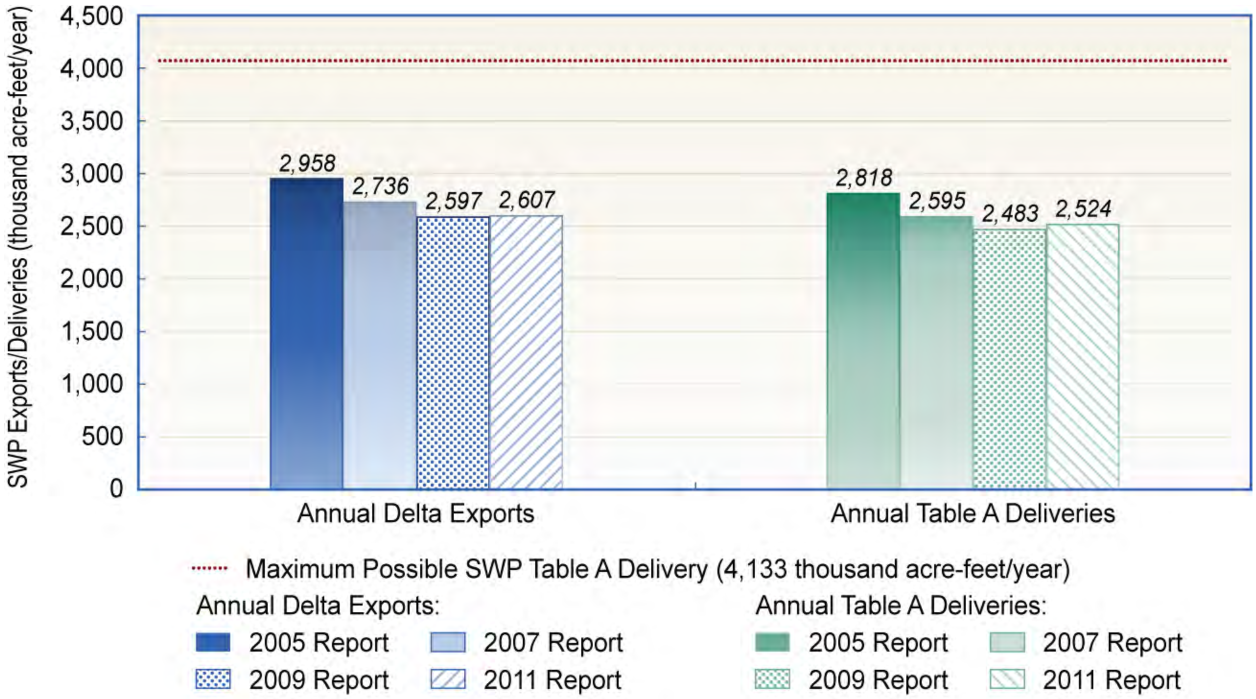


Figure 5-1. Trends in Estimated Average Annual Delta Exports and SWP Table A Water Deliveries (Existing Conditions)

2,524 taf/year in 2011, a decrease of 294 taf or 10.4%. The reasons for these decreases are described under "Primary Factors Affecting SWP Delta Export Operations and Table A Water Deliveries," below.

Monthly Delta Exports—2011 Scenario versus 2005 Scenario

Figure 5-2 illustrates the effects of the operational restrictions imposed by the BOs on SWP Delta exports since 2005 by comparing monthly existing-conditions exports estimated for this 2011 Report with those estimated for the 2005 Report. The bar charts show the average exports for each month under each scenario estimated for both reports.

As shown in Figure 5-2, average monthly SWP Delta exports estimated for the 2011 Report are lower than those estimated for the 2005 Report both in the first half of the year and from October through December. The reductions in exports for January through June are substantial, ranging from 22% in June to 58% in April. Exports for July and August as estimated for the 2011 Report exceed those estimated for the 2005 Report, but the increases (17% in August and approximately 45% in July) are generally smaller than the reductions seen earlier in the year.

Compiling the monthly average values for exports for the entire year under each scenario reveals that, as indicated previously in the description of annual exports, the average annual exports estimated for the 2011 Report are 11.9% less than those estimated for the 2005 Report.

Primary Factors Affecting SWP Delta Export Operations and Table A Water Deliveries

Under current operational constraints on the SWP, maximum exports from the Banks Pumping Plant are generally limited to 6,680 cubic feet per second, except between December 15 and March 15, when exports can be increased by one-third of the San Joaquin River

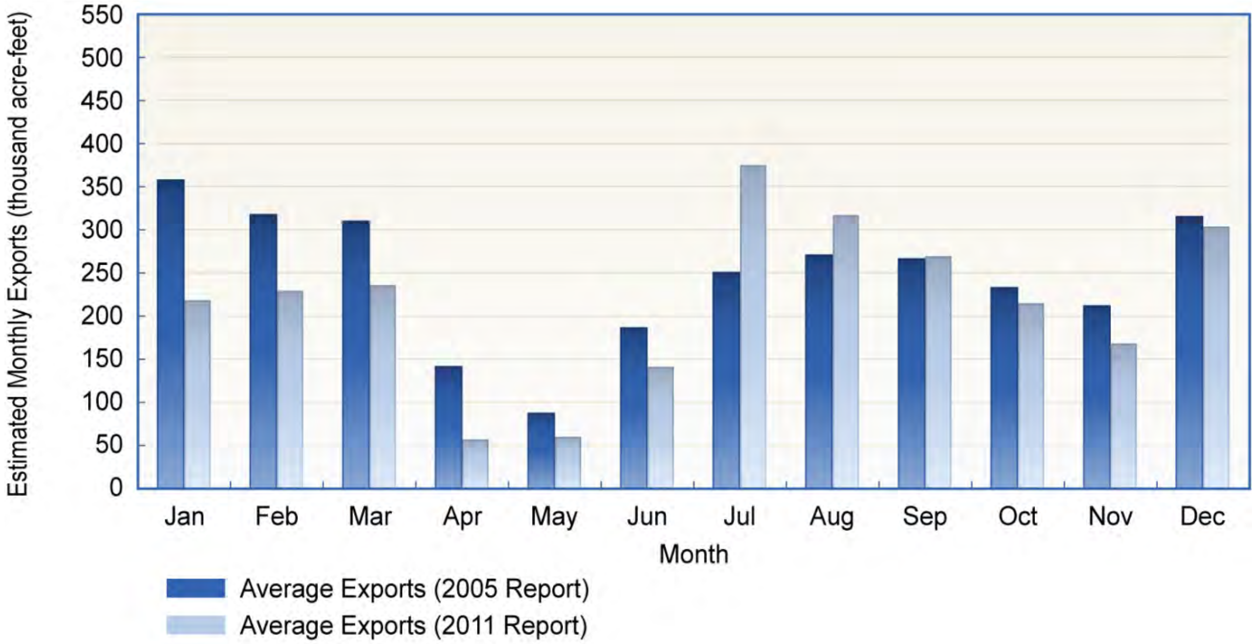


Figure 5-2. Estimated Monthly SWP Delta Exports (Existing Conditions), 2011 Scenario versus 2005 Scenario

flow at the Vernalis gauge (when the Vernalis flow is greater than 1,000 cubic feet per second). As explained previously in Chapter 4, regulatory restrictions on the SWP's Delta operations have been among the major factors affecting SWP water delivery reliability. Several of those influence SWP exports from the Banks Pumping Plant and, at times, impose particular limitations on exports. These limits are summarized here to illustrate how they affect the values shown in Figure 5-2:

- *2008 USFWS and 2009 NMFS BOs:* These BOs are much more restrictive than the BOs they replaced. The USFWS BO includes flow restrictions to protect delta smelt, with requirements in all but 2 months of the year. The NMFS BO contains similar limits for January through mid-June, but the greatest restriction imposes limits on total Delta exports in the months of April and May in most years to protect salmon and steelhead.
- *X2:* The "X2" objective mandated by the State Water Resources Control Board (State Water Board) regulates Delta salinity levels in the months of February–June. For the X2 position to be located in the appropriate location to achieve the State Water Board's salinity objective, Delta outflow must be at certain specified levels at certain times between February and June—which can constrain SWP pumping at the Banks Pumping Plant at those times.
- *Export/inflow ratio:* The 1995 *Water Quality Control Plan for the San Francisco Bay/ Sacramento–San Joaquin Delta* and State Water Board Decision 1641 (D-1641) limits Delta exports to 35% of total Delta inflow from February through June. Thus, even if substantial runoff occurs during those months (such as during a year with considerable rain-on-snow events, projected to be more likely as the effects of climate change increase), the SWP is limited in its ability to benefit from the availability of that extra water in the Delta by increasing its pumping beyond this limit. Allowable exports increase to 65% of inflow from July through January.
- *Spring Export Limitations:* Spring is an important time in the life cycles of fish

protected by the USFWS and NMFS BOs. As a result, requirements for Delta exports exist in several places. D-1641 limits SWP and CVP exports to 100% of the base flow of the San Joaquin River for 31 days during the April/May period. The NMFS BO limits the combined exports during all of April and May to a given percentage of the flow: 25% during above-normal and wet years to 100% in critical years. Finally, the previously mentioned flow requirements contained in the USFWS BO to protect delta smelt can also restrict exports during this time.

Figure 5-2 shows reductions in the values estimated for the 2011 Report during January through June and October through December that result from these restrictions. The period of July through September is the time when exports are less restricted. As a result—and to recover some of the water supply lost during the other months—the exports estimated for the 2011 Report for July–September are higher than those estimated for the 2005 Report.

Another factor described in Chapter 4, climate change, is expected to affect the Delta—and SWP exports from the Banks Pumping Plant—under future conditions. The effects of climate change on SWP operations have been factored into DWR's modeling for future conditions.

Estimated SWP Export Amounts—Existing Conditions and Future Conditions

This section provides estimates of average, maximum, and minimum annual Delta exports for both existing (2011) and future (2031) conditions. (Discussions of the assumptions used to develop both existing and future scenarios for this report are included in Chapters 6 and 7, respectively.) This section also summarizes SWP Delta exports by month and by water year type, demonstrating the effects of the USFWS and NMFS BOs and other factors influencing SWP Delta exports.

Average, Maximum, and Minimum Annual Delta Exports

Table 5-1 presents the estimated average, maximum, and minimum annual SWP Delta exports for the existing-conditions and future-conditions scenarios.

Table 5-1. Estimated Average, Maximum, and Minimum Annual SWP Exports (Existing and Future Conditions)

	Existing	Future
Average	2,607	2,521
Maximum	4,066	4,106
Minimum	876	810

Table 5-2. Average Estimated SWP Exports by Month (Existing and Future Conditions)

Month	Estimated SWP Exports (thousand acre-feet)		Difference, Existing vs. Future Conditions (thousand acre-feet and %)
	Existing	Future	
January	214	217	+4 (+2%)
February	228	217	-10 (-5%)
March	232	228	-5 (-2%)
April	60	65	+5 (+8%)
May	65	67	+2 (+4%)
June	145	131	-14 (-9%)
July	365	352	-12 (-3%)
August	316	311	-6 (-2%)
September	268	271	+3 (+1%)
October	223	186	-37 (-16%)
November	174	169	-5 (-3%)
December	317	305	-12 (-4%)

Exports by Month

Table 5-2, above, shows the average estimated SWP exports from the Delta by month under existing and future conditions. As shown in the table, in most months, the average estimated monthly SWP exports for future conditions are generally similar to or slightly lower than the estimated monthly exports for existing conditions. The most notable exceptions are in

April and May. Under both existing and future conditions, the values for those months are essentially the same, reflecting the regulations in place during that time of the year.

Figure 5-3 depicts the annual pattern of the monthly values for existing conditions as well as the maximum and minimum estimated exports for each month. The pattern and ranges of the monthly values under future conditions are very similar to those shown in Figure 5-3.

As shown in Figure 5-3 and Table 5-2, estimated SWP exports are highest on average in July, averaging 365 taf under existing conditions and 352 taf under future conditions. Exports are consistently lowest in April and May, averaging 60 taf in April and 65 taf in May for 2011, and 65 taf in April and 67 taf in May for 2031.

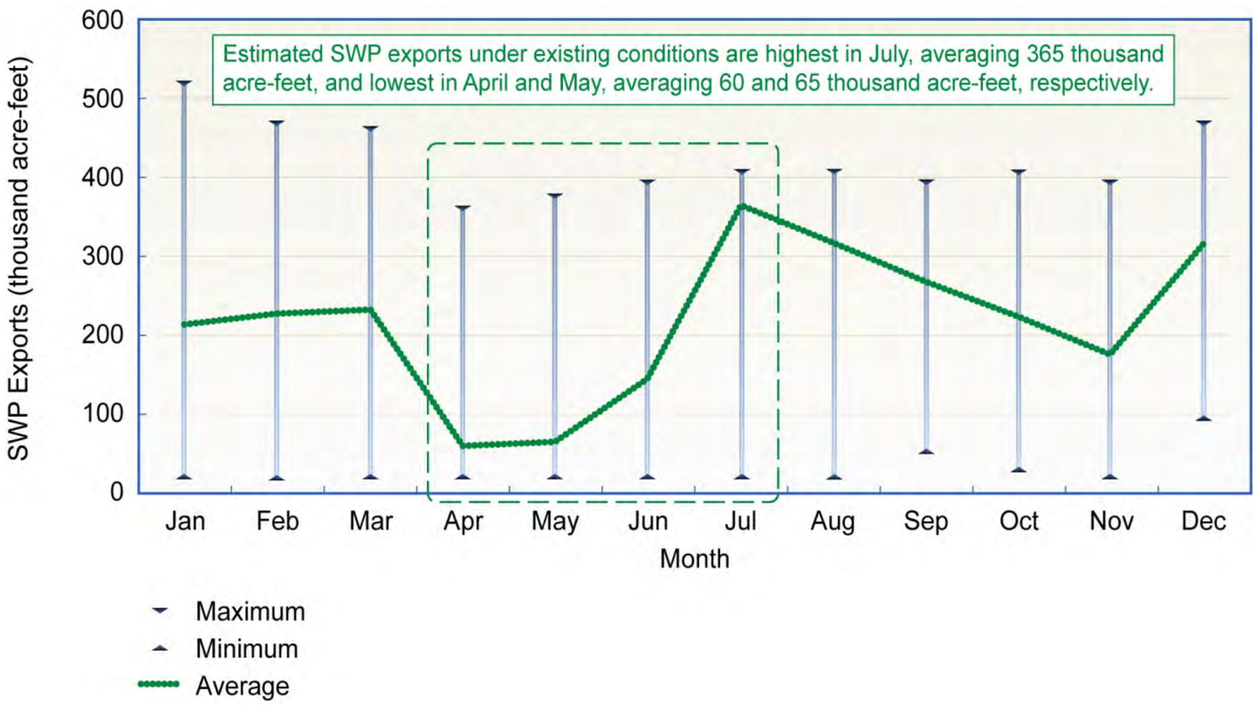


Figure 5-3. Monthly Range of Estimated SWP Exports (Existing Conditions)

Exports by Water Year Type

Tables 5-3 and 5-4 compare SWP exports by water year type under existing conditions and future conditions, as estimated for the 2009 Report and for this 2011 Report. As shown, the existing SWP exports estimated for this 2011 Report are very similar to the existing SWP exports estimated for the 2009 Report for most water year types. The same can be said of the values estimated for future conditions.

Table 5-3. Estimated SWP Exports by Water Year Type—Existing Conditions

Water Year Type	Estimated Existing SWP Exports (thousand acre-feet)	
	2009 Report	2011 Report
Wet	3,233	3,210
Above Normal	2,774	2,784
Below Normal	2,617	2,643
Dry	2,290	2,320
Critical	1,486	1,512
Average	*2,598*	*2,607*

Table 5-4. Estimated SWP Exports by Water Year Type—Future Conditions

Water Year Type	Estimated Future SWP Exports (thousand acre-feet)	
	2009 Report	2011 Report
Wet	3,196	3,182
Above Normal	2,734	2,753
Below Normal	2,557	2,556
Dry	2,173	2,120
Critical	1,526	1,414
Average	*2,550*	*2,521*

Likelihood of SWP Exports—Existing and Future Conditions

The estimated likelihood of a given level of SWP exports under existing conditions and under future conditions is presented in Figure 5-4. As shown in the figure, 4,106 taf is the largest export amount that was modeled for the 2011 Report.

As shown in Figure 5-4, in 79% of simulated cases for existing conditions, estimated SWP exports are between 2,000 and 3,500 taf/year. SWP exports of other amounts are less likely, with the next most likely export amount being between 1,000 and 1,500 taf/year.

Likewise, in about 76% of simulated cases for future conditions, estimated SWP exports are between 2,000 and 3,500 taf/year (Figure 5-4). SWP exports of other amounts are less likely, with the next most likely export amount again being between 1,000 and 1,500 taf/year.

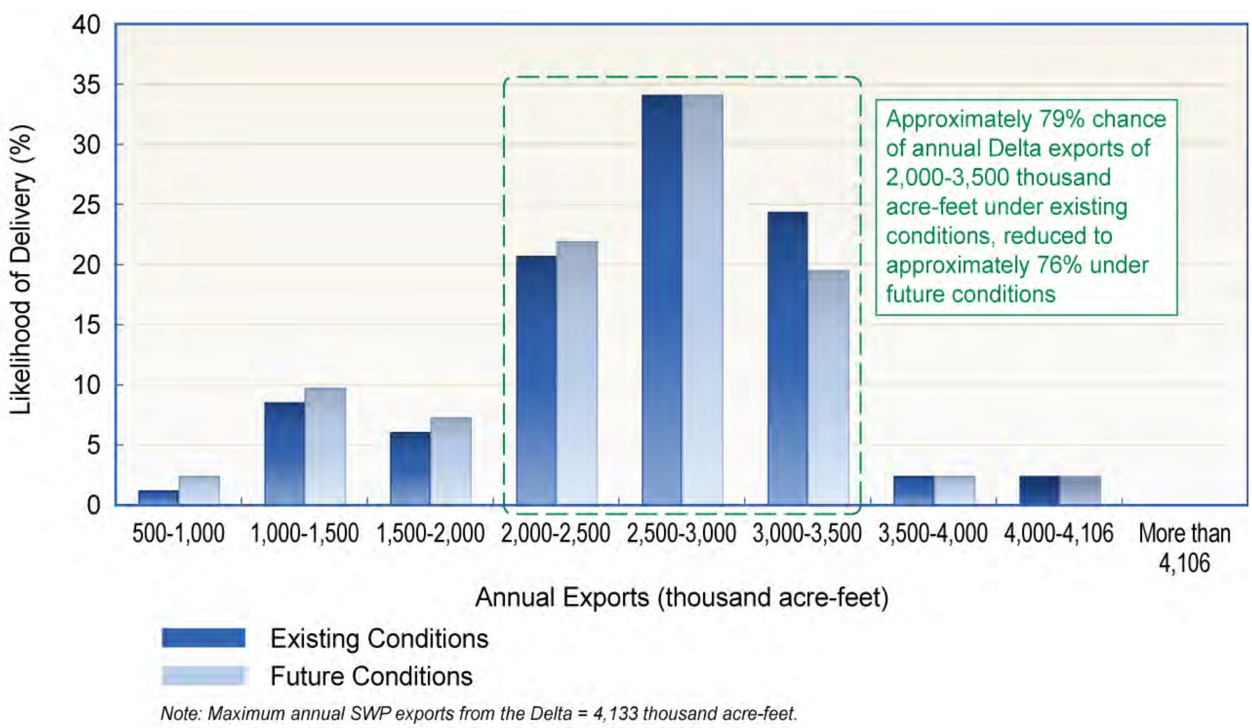


Figure 5-4. Estimated Likelihood of SWP Exports, by Increments of 500 Acre-Feet (under Existing and Future Conditions)

This page intentionally left blank.

Chapter 6

Existing SWP Water Delivery Reliability (2011)

This chapter presents estimates of the SWP's existing (2011) water delivery reliability. The estimates are presented below, alongside the reliability results obtained from the *State Water Project Delivery Reliability Report 2009* (2009 Report). Like this *State Water Project Delivery Reliability Report 2011* (2011 Report), the 2009 Report incorporated into its results the requirements of biological opinions issued by the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS) in December 2008 and June 2009, respectively, on the effects of coordinated operations of the SWP and Central Valley Project. These BOs are discussed in detail in Chapter 2, "A Closer Look at the State Water Project," and Chapter 4, "Factors that Affect Water Delivery Reliability."

The discussions of SWP water delivery reliability in this chapter and Chapter 7 present the results of DWR's updated modeling of the SWP's water delivery reliability. A tabular summary of the modeling results is presented in the technical addendum to this report, which is available online at http://baydeltaoffice.water.ca.gov/. The technical addendum also contains curves of annual delivery probability (i.e., exceedence plots) to graphically show the estimated percentage of years in which a given annual delivery is equaled or exceeded.

Hydrologic Sequence

SWP delivery amounts are estimated in this 2011 Report for existing conditions using computer modeling that incorporates the historic range of hydrologic conditions (i.e., precipitation and runoff) that occurred from water years 1922 through 2003. The historic hydrologic conditions are adjusted to account for land-use changes (i.e., the current level of development) and upstream flow regulations that characterize 2011. By using this 82-year historical flow record, the delivery estimates modeled for existing conditions reflect a reasonable range of potential hydrologic conditions from wet years to critically dry years.

Existing Demand for Delta Water

Demand levels for the SWP water users in this report are derived from historical data and information from the SWP contractors themselves. The amount of water that SWP contractors request each year (i.e., demand) is related to:

- the magnitude and types of water demands,
- the extent of water conservation measures,
- local weather patterns, and
- water costs.

The existing level of development (i.e., the level of water use in the source areas from which the water supply originates) is based on recent land uses, and is assumed to be representative of existing conditions for the purposes of this 2011 Report.

SWP Table A Water Demands

The current combined maximum Table A amount is 4,172 thousand acre-feet per year (taf/year). See "'Table A' Water" in Chapter 3, "SWP Contractors and Water Contracts," for a full discussion of Table A, which is a table within each water supply contract. Of the combined maximum Table A amount, 4,133 taf/year is the SWP's maximum Table A water available for delivery from the Delta. The estimated demands by SWP contractors for deliveries of Table A water from the Delta under existing conditions, as determined for the 2011 Report and previously for the 2009 Report, are shown in Table 6-1. The estimated average demand for SWP Table A water is shown, along with maximum and minimum demands, because demands vary annually depending on local hydrologic patterns and other factors (e.g., demand management and the amount of water storage within the service area).

Table 6-1. Comparison of Estimated Average, Maximum, and Minimum Demands for SWP Table A Water (Existing Conditions)

	2009 Report	2011 Report
Average	3,711	3,722
Maximum	4,115	4,120
Minimum	3,007	3,043

As estimated for the 2011 Report, annual demands for SWP Table A water range between 3,043 taf and 4,120 taf under existing conditions, with an average demand of 3,722 taf. There is a 95% likelihood that more than 3,200 taf/year will be requested (i.e., demanded) for delivery under existing conditions. The estimated maximum SWP Table A water demand in the 2011 Report is very near the maximum possible Table A water delivery amount of 4,133 taf/year; however, the average annual demand of 3,722 taf is approximately 400 taf less than the possible maximum annual delivery.

Figure 6-1 shows that estimated annual demands for deliveries of SWP Table A water, as calculated for the 2009 and 2011 Reports, are essentially the same. Demands calculated for both reports range between 3,000 and 4,120 taf/year, regardless of whether a year is critical, wet, or anywhere in between.

SWP Article 21 Water Demands

Under Article 21 of the SWP's long-term water supply contracts, contractors may receive additional water deliveries only under the following specific conditions:

- such deliveries do not interfere with SWP Table A allocations and SWP operations;
- excess water is available in the Delta;
- capacity is not being used for SWP purposes or scheduled SWP deliveries; and
- contractors can use the SWP Article 21 water directly or can store it in their own system (i.e., the water cannot be stored in the SWP system).

The demand for SWP Article 21 water by SWP contractors is assumed to vary depending on the month and weather conditions (i.e., amounts of precipitation and runoff). For the purposes of this discussion of SWP Article 21 water demands, a Kern wet year is defined as a year when the annual Kern River flow is projected to be greater than 1,500 taf. Kern River inflows are significant

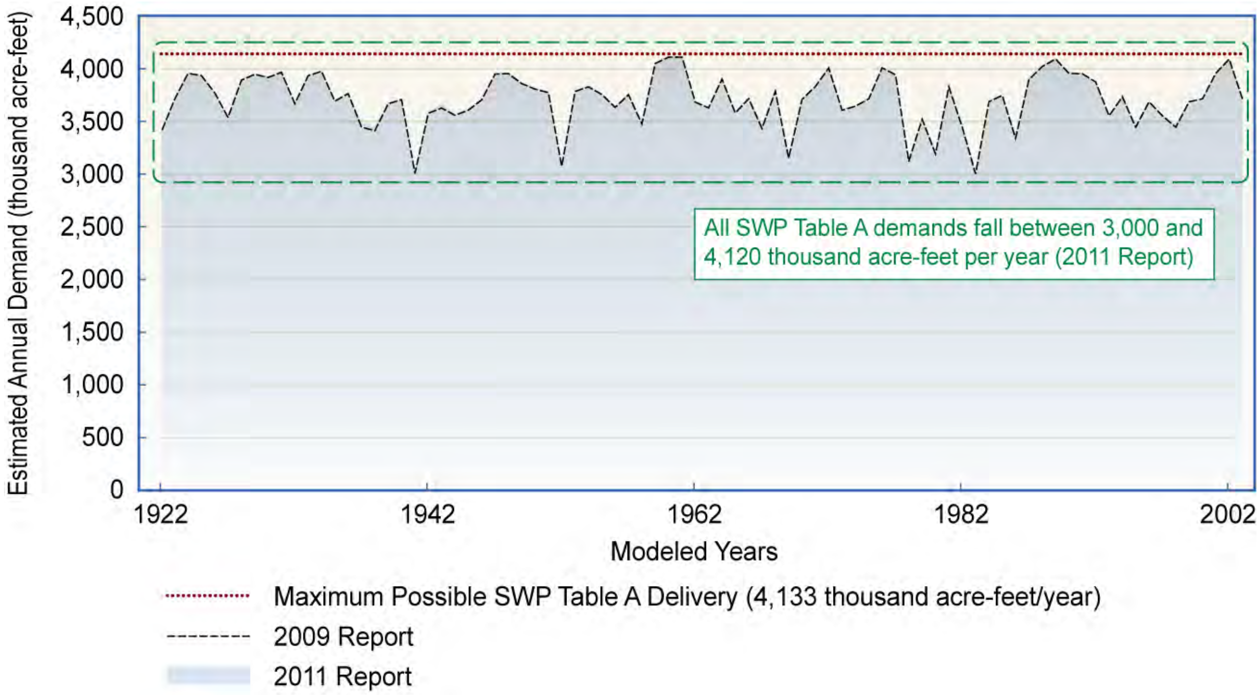


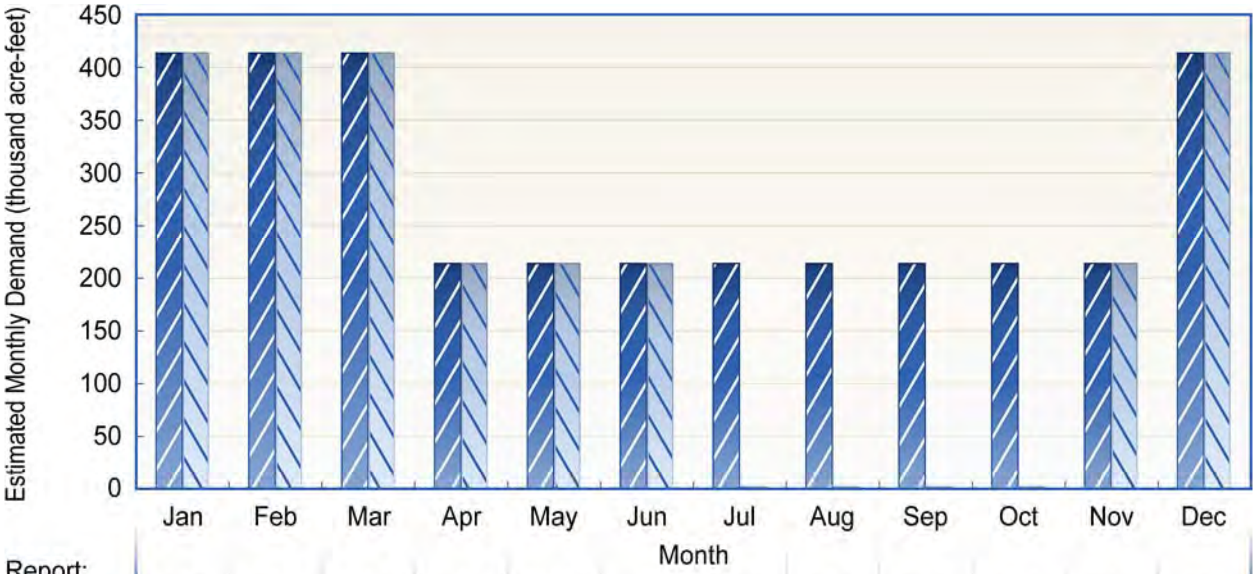
Figure 6-1. Comparison of Estimated Demands for SWP Table A Water on an Annual Basis, Using 82 Years of Hydrology (Existing Conditions)

because they are a major local water supply component for the Kern County Water Agency, which is the second largest SWP contractor and possesses significant local groundwater recharge capability. Using Kern River flows to recharge their groundwater storage significantly reduces their demand for Article 21 supply.

As shown in Figures 6-2 and 6-3, existing demands for SWP Article 21 water estimated for this 2011 Report are assumed to be high during the spring and late fall in non–Kern wet years (214 taf/month), as well as during the winter months of December through March in all weather year types (202 taf in Kern wet years and 414 taf in other years). Demands for SWP Article 21 water are assumed to be very low (2 taf/month) from April through November of Kern wet years and from July through October of other years.

Relative to levels of demand for SWP Article 21 water presented in the 2009 Report for existing conditions, the monthly existing-conditions demands for Article 21 water are 212 taf lower from July through October in normal weather years. This reduction in demand occurs because the modeling was revised for the 2011 Report to assume that only SWP contractors receiving water from the North Bay Aqueduct will have SWP Article 21 water demands during those months. A second revision to the modeling assumptions relative to the 2009 Report resulted in the addition of a year-round demand for 2 taf/month through the North Bay Aqueduct in 2011 during wet weather years.

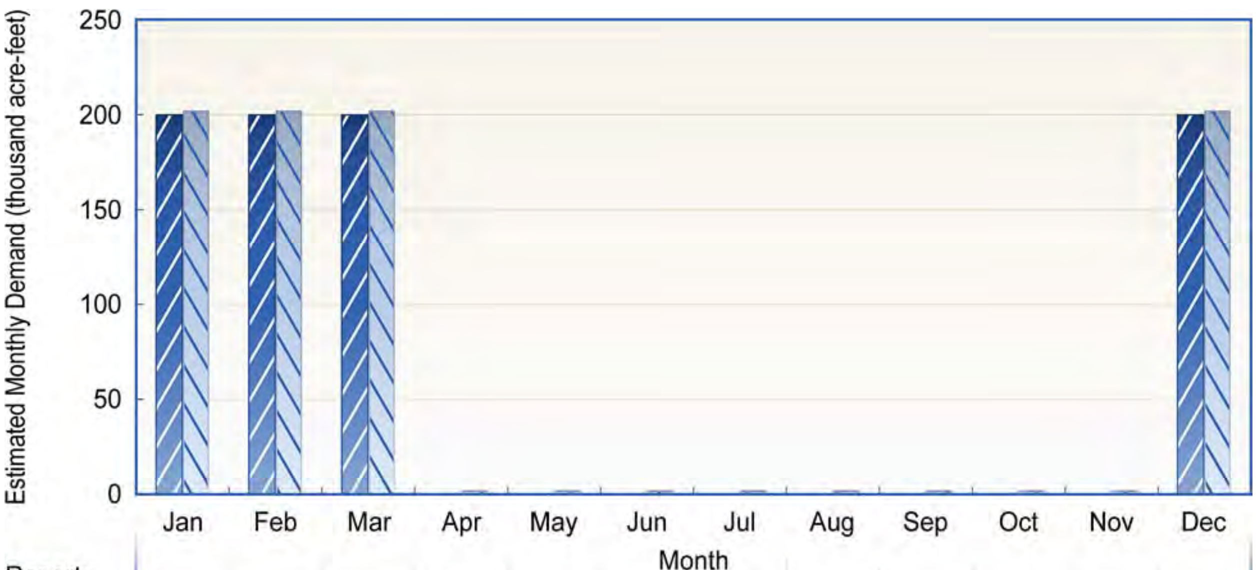
The estimated reduction in existing-conditions demand for SWP Article 21 water in this 2011 Report relative to the 2009 Report is the result of discussions with DWR's Operations and Maintenance staff and State Water Contractors staff, and it represents their best estimates of current practices. The SWP Article 21 water demands used in the 2009 Report, on the other



Report:	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2009	414	414	414	214	214	214	214	214	214	214	214	414
2011	414	414	414	214	214	214	2	2	2	2	214	414

Figure note: Values shown are the maximum amount that can be delivered monthly. However, the actual capability of SWP water contractors to take this amount of SWP Article 21 water is not the sum of these maximum monthly values.

Figure 6-2. Estimated Demands for SWP Article 21 Water in Years When Kern River Flow is Less than 1,500 Thousand Acre-Feet (Existing Conditions)



Report:	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2009	200	200	200	0	0	0	0	0	0	0	0	200
2011	202	202	202	2	2	2	2	2	2	2	2	202

Figure note: Values shown are the maximum amount that can be delivered monthly. However, the actual capability of SWP water contractors to take this amount of SWP Article 21 is not the sum of these maximum monthly values.

Figure 6-3. Estimated Demands for SWP Article 21 Water in Years When Kern River Flow is Greater than 1,500 Thousand Acre-Feet (Existing Conditions) hand, match the demands assumed in the studies conducted for the 2008 USFWS BO and 2009 NMFS BO, and those demands capture the upper boundary of the potential impact of SWP Article 21 exports on the Delta ecosystem. This assumption reflects a condition in which SWP contractors are able to use essentially any available SWP Article 21 water when capacity for moving that water exists in the SWP delivery system.

Estimates of SWP Table A Water Deliveries

Table 6-2 presents the annual average, maximum, and minimum estimates of SWP Table A deliveries from the Delta for existing conditions, as calculated for the 2009 and 2011 Reports. The Table A deliveries are similar between the 2009 and 2011 Reports. Assumptions about Table A and Article 21 water demands, along with operations for carryover water, have been updated in the model based on discussions with State Water Contractors staff and DWR's Operations and Control Office.

Table 6-2. Comparison of Estimated Average, Maximum, and Minimum Deliveries of SWP Table A Water (Existing Conditions, in Thousand Acre-Feet per Year)

	2009 Report	2011 Report
Average	2,483	2,524
Maximum	3,338	3,365
Minimum	301	380

The estimated likelihood of delivery of a given amount of SWP Table A water under the existing conditions scenario, as estimated for both the 2009 and 2011 Reports, is presented in Figure 6-4. Figure 6-4 shows that the likelihood that 2,000–3,365 taf/year of Table A water will be delivered is now 82%. There is a 48% likelihood that 2,500–3,000 taf of Table A water will be delivered, a 5% likelihood of delivery of less than 1,000 taf, and 0% likelihood of delivery of more than 3,365 taf in a given year. To compare the results estimated for this 2011 Report with results from the 2009 Report, an SWP contractor is just slightly more likely to receive a larger Table A water delivery under the current estimates.

Dry-Year Deliveries of SWP Table A Water

Table 6-3 displays estimates of SWP Table A water deliveries under existing conditions during possible drought conditions and compares them with the corresponding delivery estimates calculated for the 2009 Report. Droughts are analyzed using the historical drought-period precipitation and runoff patterns from 1922 through 2003 as a reference, although existing 2011 conditions (e.g., land use, water infrastructure) are also accounted for in the modeling. For reference, the worst multiyear drought on record was the 1929–1934 drought, although the brief drought of 1976–1977 was more intensely dry.

The results of modeling existing conditions for potential drought-year scenarios indicate that SWP Table A water deliveries during dry years can be expected to range from between 380 and 1,573 taf/year.

Wet-Year Deliveries of SWP Table A Water

Table 6-4 presents estimates of SWP Table A water deliveries under existing conditions during possible wet conditions and compares them with corresponding delivery estimates calculated for the 2009 Report. Wet periods for 2011 are analyzed using historical precipitation and runoff patterns from 1922–2003 as a reference, while accounting for existing 2011 conditions (e.g., land use, water infrastructure). For reference, the wettest single year on record was 1983.

The results of modeling existing conditions for potential wet periods indicate that estimated SWP Table A water deliveries during wet years can be expected to range between 2,833 and 2,958 taf/year.

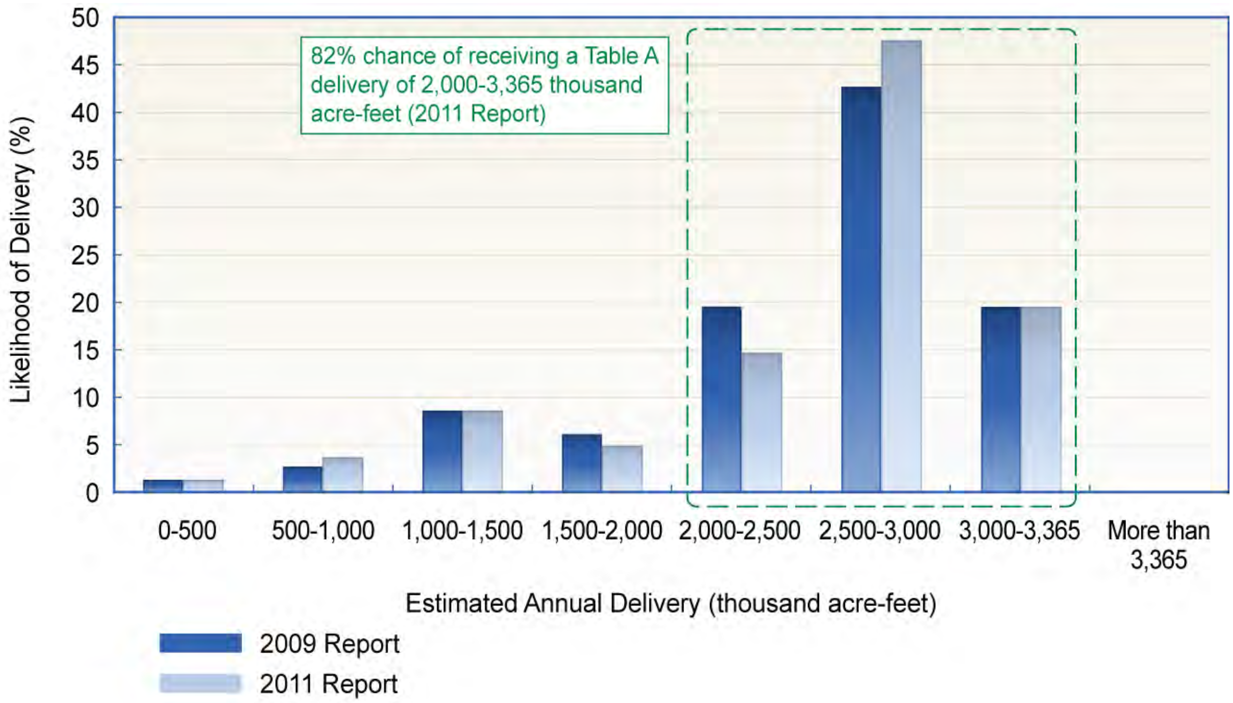


Figure 6-4. Estimated Likelihood of SWP Table A Water Deliveries (Existing Conditions)

Table 6-3. Estimated Average and Dry-Period Deliveries of SWP Table A Water (Existing Conditions), in Thousand Acre-Feet (Percent of Maximum SWP Table A Amount, 4,133 taf/year)

	Long-term Average	Single Dry Year (1977)	2-Year Drought (1976–1977)	4- Year Drought (1931–1934)	6-Year Drought (1987–1992)	6-Year Drought (1929–1934)
2009 Report	2,483 (60%)	302 (7%)	1,496 (36%)	1,402 (34%)	1,444 (35%)	1,398 (34%)
2011 Report	2,524 (61%)	380 (9%)	1,573 (38%)	1,454 (35%)	1,462 (35%)	1,433 (35%)

Table 6-4. Estimated Average and Wet-Period Deliveries of SWP Table A Water (Existing Conditions), in Thousand Acre-Feet (Percent of Maximum SWP Table A Amount, 4,133 taf/year)

	Long-term Average	Single Wet Year (1983)	2-Year Wet (1982–1983)	4-Year Wet (1980–1983)	6-Year Wet (1978–1983)	10-Year Wet (1978–1987)
2009 Report	2,483 (60%)	2,813 (68%)	2,935 (71%)	2,817 (68%)	2,817 (68%)	2,872 (67%)
2011 Report	2,524 (61%)	2,886 (70%)	2,958 (72%)	2,872 (69%)	2,873 (70%)	2,833 (69%)

Estimates of SWP Article 21 Water Deliveries

SWP water delivery is a combination of deliveries of Table A water and Article 21 water. Some SWP contractors store Article 21 water locally when extra water and capacity are available beyond that needed by normal SWP operations. Deliveries of SWP Article 21 water vary not only by year, but also by month. In the summer and early fall months (July through October), a maximum of 1 taf can be delivered. From November through June, maximum deliveries of SWP Article 21 water can be as high as 299 taf and as low as approximately 80 taf in a given month; however, water deliveries average in the range of 0–30 taf. The estimated range of monthly deliveries of SWP Article 21 water is displayed in Figure 6-5.

The estimated likelihood that a given amount of SWP Article 21 water will be delivered is presented in Figure 6-6. There is a 26% likelihood that more than 20 taf/year of SWP Article 21 water will be delivered under existing conditions. There is a 74% likelihood that less than 20 taf/year of SWP Article 21 water will be delivered.

Dry-Year Deliveries of SWP Article 21 Water

Although deliveries of SWP Article 21 water are smaller during dry years than during wet ones, opportunities exist to deliver SWP Article 21 water during multiyear drought periods. Deliveries in dry years are shown to often be small (less than 5 taf); however, longer drought periods can include several years that support Article 21 deliveries. Annual average Article 21 estimates for drought periods of 4 and 6 years vary significantly and can approach or exceed the average annual estimate, as shown in Table 6-5.

Wet-Year Deliveries of SWP Article 21 Water

Table 6-6 shows the estimates of deliveries of SWP Article 21 water during wet periods under existing conditions. Estimated deliveries in wet years are approximately 1.75 to seven times larger than the average delivery of SWP Article 21 water.

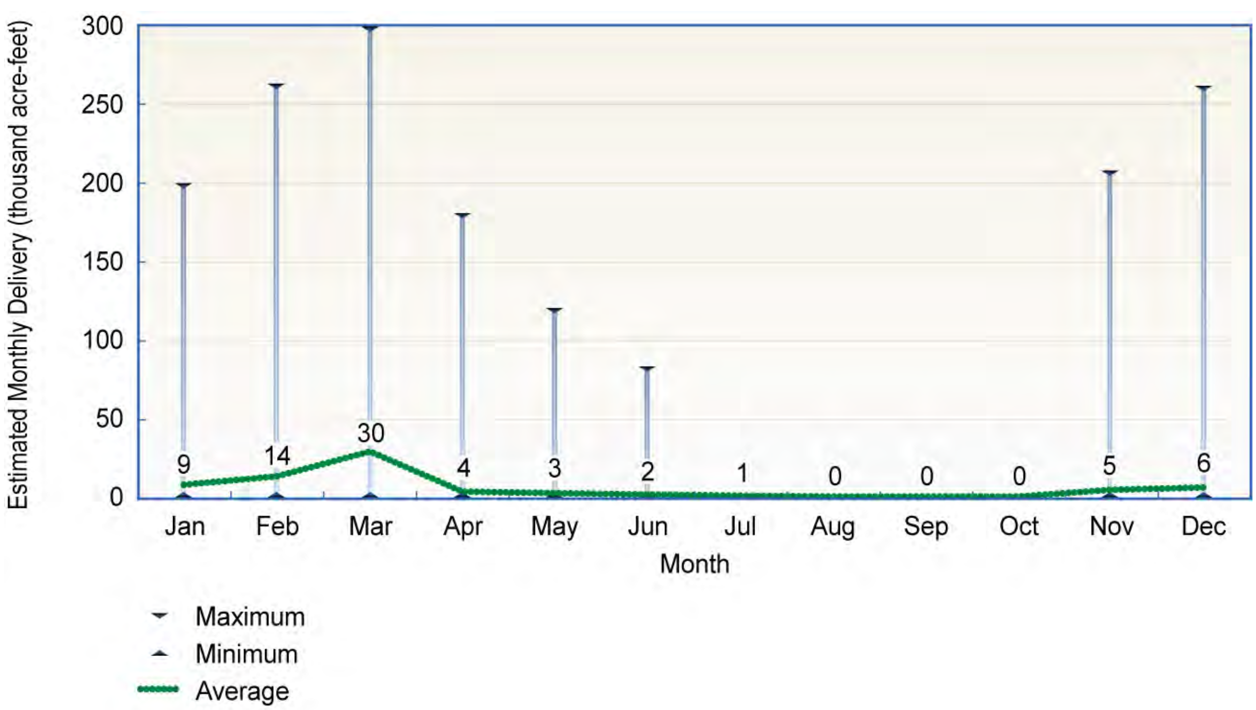


Figure 6-5. Estimated Range of Monthly Deliveries of SWP Article 21 Water (2011 Report—Existing Conditions)

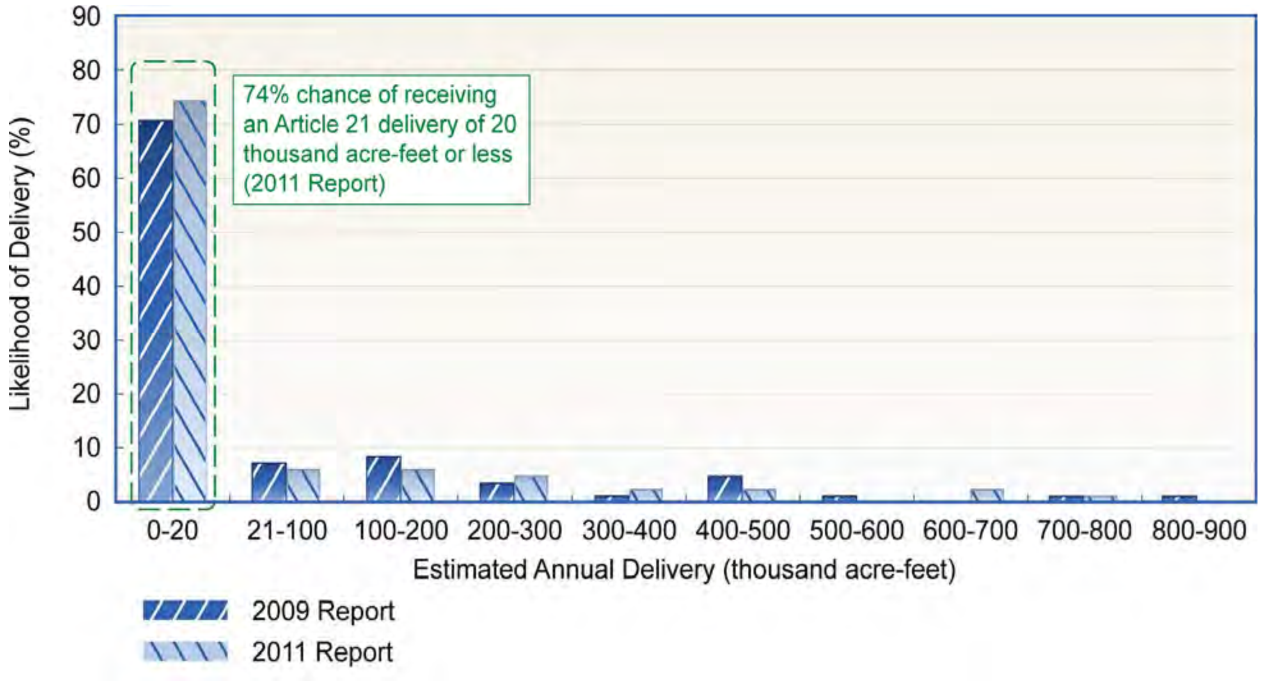


Figure 6-6. Estimated Probability of Annual Deliveries of SWP Article 21 Water (Existing Conditions)

Table 6-5. Estimated Average and Dry-Period Deliveries of SWP Article 21 Water (Existing Conditions, in Thousand Acre-Feet per Year)

	Long-term Average	Single Dry Year (1977)	2-Year Drought (1976-1977)	4- Year Drought (1931-1934)	6-Year Drought (1987-1992)	6-Year Drought (1929-1934)
2009 Report	85	2	6	142	10	98
2011 Report	76	3	5	69	9	49

Table 6-6. Estimated Average and Wet-Period Deliveries of SWP Article 21 Water (Existing Conditions, in Thousand Acre-Feet per Year)

	Long-term Average	Single Wet Year (1983)	2-Year Wet (1982-1983)	4-Year Wet (1980-1983)	6-Year Wet (1978-1983)	10-Year Wet (1978-1987)
2009 Report	85	853	659	379	273	230
2011 Report	76	608	533	307	225	207

Chapter 7

Future SWP Water Delivery Reliability (2031)

This chapter presents estimates of the SWP's delivery reliability for conditions 20 years in the future (2031). These estimates reflect hydrologic changes that could result from climate change, but they incorporate the same requirements that are assumed under existing conditions, including the U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) biological opinions (BOs).

This chapter also compares these estimates of future conditions with the future-condition results presented in the *State Water Project Delivery Reliability Report 2009* (2009 Report) for the year 2029.

For consistency with previous reports, a tabular summary of the modeling results for the future conditions scenario is presented in the technical addendum to this report. The technical addendum also contains curves of annual delivery probability (i.e., exceedence plots) to graphically show the estimated percentage of years in which a given annual delivery is equaled or exceeded.

Future Demand for Delta Water

Demand levels for the SWP water users in this report are derived from historical data and information from the SWP contractors themselves. The 2031 level of development (i.e., the level of water use in the source areas from which the water supply originates) is based on the projected assumptions for land use for that year, and is assumed to be representative of future conditions for the purposes of this 2011 Report.

SWP Table A Water Demands

Future demands for SWP Table A water, as calculated for this 2011 Report, are assumed to be the maximum possible annual amount of 4,133 thousand acre-feet (taf). There is no assumed variation in demand as a result of different annual precipitation and runoff conditions; it is assumed that by 2031, the maximum amount of SWP Table A water will be requested every year. As a reminder, 4,133 taf/year is the maximum Delta SWP Table A amount.

The SWP Table A water demands under future conditions as presented in the 2009 Report are also assumed to be the maximum amount of 4,133 taf/year.

SWP Article 21 Water Demands

The assumed future demands for SWP Article 21 water are the same as those assumed for existing conditions (see Chapter 6, "Existing SWP Water Delivery Reliability [2011]").

Estimates of Future SWP Deliveries

When modeling water supply deliveries 20 years in the future, the unknowns are considerable and many assumptions must be made. As was assumed for existing conditions (see Chapter 6), modeling of SWP deliveries for 2031 take into account current Delta water quality regulations and the requirements of the USFWS and NMFS BOs. Climate change as well as changes to water uses in the upstream watersheds (i.e., source watersheds) are also taken into account when modeling water supply deliveries under future conditions. Additional discussion of how the modeling of SWP water delivery reliability is adjusted to account for climate change is provided in Chapter 4, "Factors that Affect Water Delivery Reliability."

One of the most important assumptions when modeling SWP water delivery under future conditions is that the rules and facilities related to Delta conveyance will remain at the status quo. That is, in the future-conditions scenario, no new facilities to convey water through or around the Delta are assumed to be in place because no new programs have been sufficiently developed that can be assumed with certainty.

Future Deliveries of SWP Table A Water

Table 7-1 presents the annual average, maximum, and minimum estimates of SWP Table A water deliveries from the Delta for future conditions, as calculated for the 2009 and 2011 Reports. The SWP Table A water deliveries under future conditions are similar between the 2009 and 2011 Reports. The maximum possible delivery of SWP Table A water, 4,133 taf/year, is not reached under future conditions.

Table 7-1. Comparison of Estimated Average, Maximum, and Minimum Deliveries of SWP Table A Water (Future Conditions, in Thousand Acre-Feet per Year)

	2009 Report	2011 Report
Average	2487	2,466
Maximum	3,999	4,063
Minimum	458	443

The estimated likelihood that a given amount of SWP Table A water will be delivered under future conditions is presented in Figure 7-1. Currently, there is a 70% likelihood that 2,000–3,500 taf of SWP Table A water will be delivered under the future-conditions scenario. There is a 17% likelihood of an SWP Table A water delivery of 1,000–2,000 taf, a 7% likelihood of less than 1,000 taf, and a 6% likelihood of more than 3,500 taf. In general, the estimates of the likelihood that an SWP contractor will receive a specific amount of SWP Table A water under future conditions, as presented in the 2009 and 2011 Reports, are very similar.

Dry-Year Deliveries of SWP Table A Water under Future Conditions

Table 7-2 presents estimates of future SWP Table A water deliveries during possible drought conditions and compares them with the corresponding delivery estimates calculated for the 2009 Report. Drought scenarios for future conditions in this 2011 Report are analyzed using the historical drought-period precipitation and runoff patterns from 1922–2003 as a reference, while accounting for future 2031 conditions (e.g., land use, climate change).

The results of modeling future conditions under potential drought-year scenarios indicate that estimated dry-year SWP deliveries can be expected to range between 443 and 1,457 taf/year.

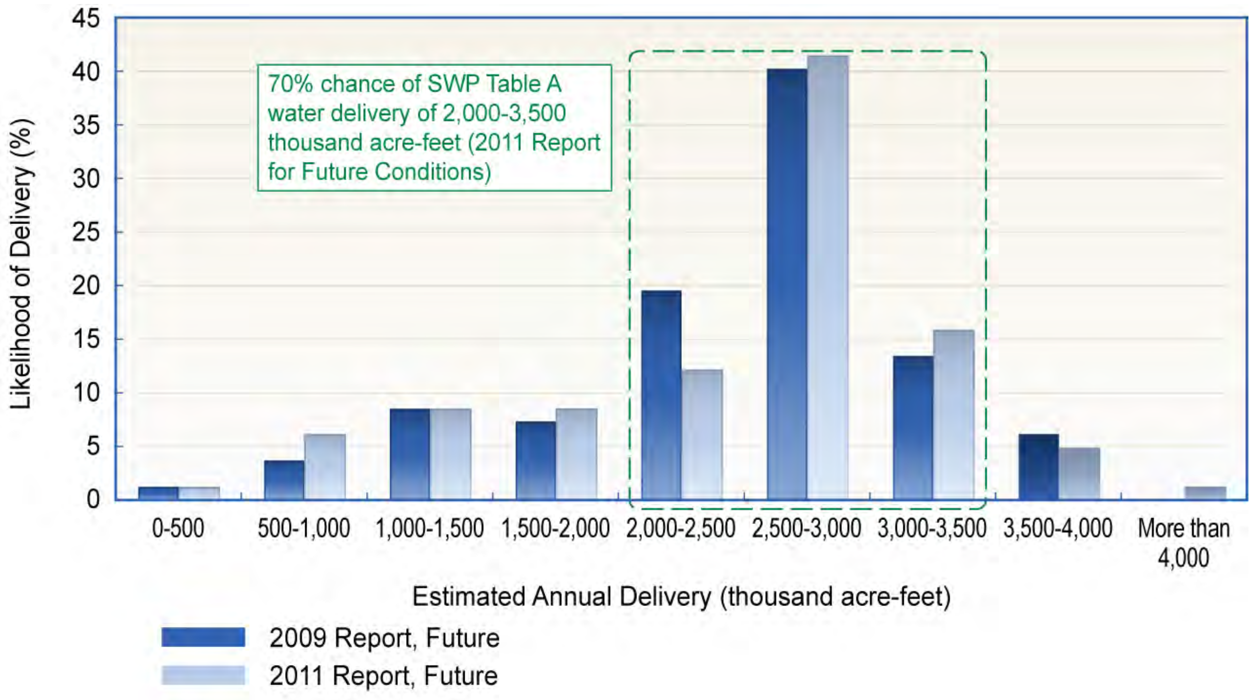


Figure 7-1. Estimated Likelihood of SWP Table A Water Deliveries, by Increments of 500 Thousand Acre-Feet (Future Conditions)

Table 7-2. Estimated Average and Dry-Period Deliveries of SWP Table A Water (Future Conditions), in Thousand Acre-Feet (Percent of Maximum SWP Table A Amount, 4,133 taf/year)

	Long-term Average	Single Dry Year (1977)	2-Year Drought (1976–1977)	4- Year Drought (1931–1934)	6-Year Drought (1987–1992)	6-Year Drought (1929–1934)
2009 Report	2,487 (60%)	458 (11%)	1,570 (38%)	1,431 (35%)	1,308 (32%)	1,480 (36%)
2011 Report	2,466 (60%)	443 (11%)	1,457 (35%)	1,401 (34%)	1,227 (30%)	1,366 (33%)

Wet-Year Deliveries of SWP Table A Water under Future Conditions

Table 7-3 presents estimates of future SWP Table A water deliveries during a wet year and compares them with the corresponding delivery estimates calculated for the 2009 Report. Wet periods were modeled for this 2011 Report using historical precipitation and runoff patterns from 1922–2003 as a reference and accounting for 2031 future conditions such as land use and climate change.

The results of modeling future conditions for potential wet periods indicate that estimated SWP Table A water deliveries during wet years can be expected to range between 2,972 and 4,063 taf/year.

SWP Article 21 Water Deliveries under Future Conditions

Estimated deliveries of SWP Article 21 water under future conditions vary not only by year, depending on the precipitation and runoff, but also by month. In the spring, summer, and early fall months (May through October), deliveries of SWP Article 21 water under future conditions are estimated to be low, with a maximum of approximately 10 taf/month and a minimum of 0 taf/month. From November through April, maximum estimated future deliveries of SWP

Table 7-3. Estimated Average and Wet-Period Deliveries of SWP Table A Water (Future Conditions), in Thousand Acre-Feet (Percent of Maximum SWP Table A Amount, 4,133 taf/year)						
	Long-term Average	Single Wet Year (1983)	2-Year Wet (1982–1983)	4-Year Wet (1980–1983)	6-Year Wet (1978–1983)	10-Year Wet (1978–1987)
2009 Report	2,487 (60%)	3,990 (97%)	3,843 (93%)	3,401 (82%)	3,250 (79%)	2,975 (72%)
2011 Report	2,466 (60%)	4,063 (98%)	3,908 (95%)	3,396 (82%)	3,248 (79%)	2,972 (72%)

Article 21 water can be as high as 251 taf and as low as 50 taf in a given month; however, water deliveries average in the range of 2–22 taf. The estimated range of monthly deliveries of SWP Article 21 water is displayed in Figure 7-2.

The estimated likelihood that a given amount of SWP Article 21 water will be delivered under future conditions is presented in Figure 7-3. Currently, there is a 22% likelihood that more than 20 taf/year of SWP Article 21 water will be delivered under future conditions, and a 78% likelihood that 20 taf/year or less will be delivered.

In both the 2009 and 2011 Reports, estimated deliveries of SWP Article 21 water under future conditions are generally 20 taf/year or less (72% and 78% likelihood, respectively).

Dry-Year Deliveries of SWP Article 21 Water under Future Conditions

Table 7-4 shows the estimates of future deliveries of SWP Article 21 water during dry periods. The results of modeling future conditions for potential drought scenarios indicate that deliveries of SWP Article 21 water during dry years can be expected to range between 4 and 50 taf/year. This is a 0% to 92% decrease in Article 21 water deliveries from the average estimated future-conditions delivery calculated for this report. Although drought-period deliveries are typically less than deliveries in average years, Table 7-4 shows that opportunities to deliver SWP Article 21 water exist during multiyear drought periods.

Wet-Year Deliveries of SWP Article 21 Water under Future Conditions

Table 7-5 shows the estimates of deliveries of SWP Article 21 water during wet periods under future conditions. The results of modeling future conditions for potential wet periods indicate that wet-year SWP deliveries can be expected to range between 83 and 291 taf. This is a 66% to 483% increase in deliveries of SWP Article 21 water from the average estimated future-conditions delivery calculated for this report.

Table 7-4. Estimated Average and Dry-Period Deliveries of SWP Article 21 Water (Future Conditions, in Thousand Acre-Feet per year)						
	Long-term Average	Single Dry Year (1977)	2-Year Drought (1976–1977)	4- Year Drought (1931–1934)	6-Year Drought (1987–1992)	6-Year Drought (1929–1934)
2009 Report	60	3	7	169	27	142
2011 Report	50	4	7	50	10	37

Table 7-5. Estimated Average and Wet-Period Deliveries of SWP Article 21 Water (Future Conditions, in Thousand Acre-Feet per year)						
	Long-term Average	Single Wet Year (1983)	2-Year Wet (1982–1983)	4-Year Wet (1980–1983)	6-Year Wet (1978–1983)	10-Year Wet (1978–1987)
2009 Report	60	509	306	165	123	139
2011 Report	50	291	190	120	83	122

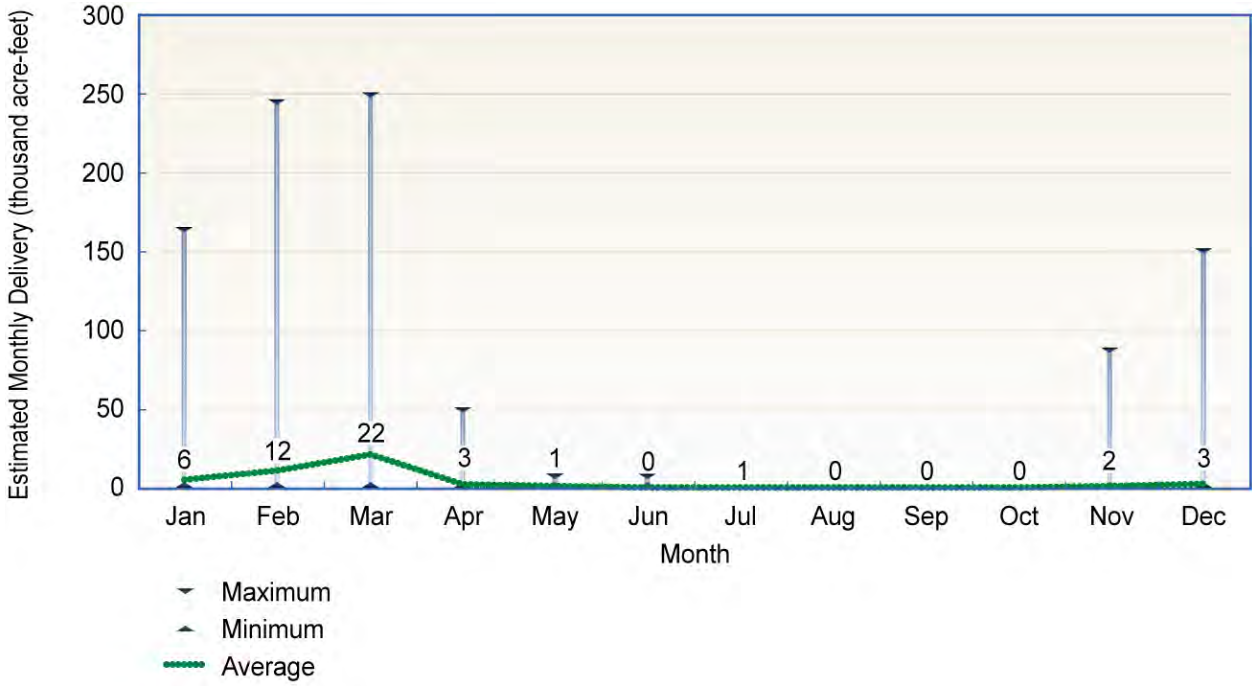


Figure 7-2. Estimated Range of Monthly Deliveries of SWP Article 21 Water (2011 Report—Future Conditions)

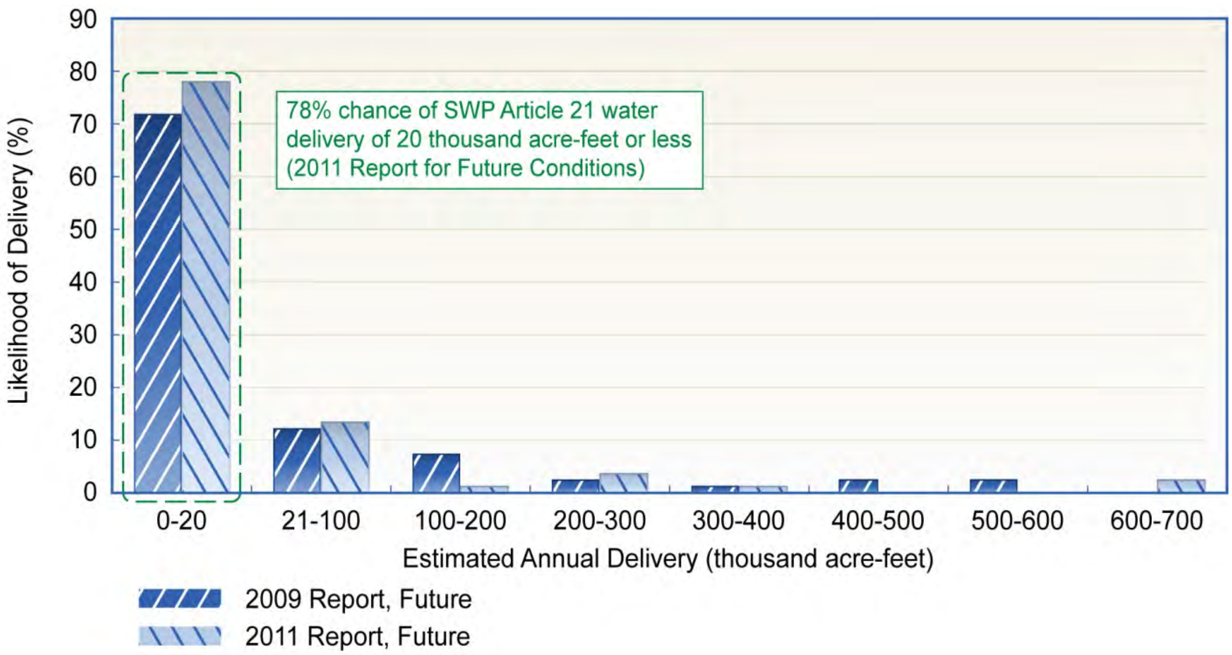


Figure 7-3. Estimated Probability of Annual Deliveries of SWP Article 21 Water (Future Conditions)

This page intentionally left blank.

Glossary

acre-foot The volume of water (about 325,900 gallons) that would cover an area of 1 acre to a depth of 1 foot. This is enough water to meet the annual needs of one to two households.

agricultural water supplier As defined by the California Water Code, a public or private supplier that provides water to 2,000 or more irrigated acres per year for agricultural purposes or serves 2,000 or more acres of agricultural land. This can be a water district that directly supplies water to farmers or a contractor that sells water to the water district.

annual Delta exports The total amount of water transferred ("exported") to areas south of the Delta through the Harvey O. Banks Pumping Plant (SWP) and the C. W. "Bill" Jones Pumping Plant (CVP) in 1 year.

appropriative water rights Rights allowing a user to divert surface water for beneficial use. The user must first have obtained a permit from the State Water Resources Control Board, unless the appropriative water right predates 1914.

Article 21 water Water that a contractor can receive in addition to its allocated Table A water. This water is only available if several conditions are met: (1) excess water is flowing through the Delta; (2) the contractor can use the surplus water or store it in the contractor's own system; and (3) delivering this water will not interfere with Table A allocations, other SWP deliveries, or SWP operations.

biological opinion A determination by the U.S. Fish and Wildlife Service or National Marine Fisheries Service on whether a proposed federal action is likely to jeopardize the continued existence of a threatened or endangered species or result in the destruction or adverse modification of designated "critical habitat." If jeopardy is determined, certain actions are required to be taken to protect the species of concern.

CALSIM II A computer model, jointly developed by DWR and the U.S. Bureau of Reclamation, that simulates existing and future operations of the SWP and CVP. The hydrology used by this model was developed by adjusting the historical flow record (1922–2003) to account for the influence of changes in land uses and regulation of upstream flows.

Among the SWP's facilities are more than 700 miles of canals that distribute water to urban and agricultural water suppliers in Northern California, the San Francisco Bay Area, the San Joaquin Valley, the Central Coast, and Southern California.

carryover deliveries See "carryover water."

carryover water A water supply "savings account" for SWP water that is allocated to an SWP contractor in a given year, but not used by the end of the year. Carryover water is stored in the SWP's share of San Luis Reservoir, when space is available, for the contractor to use in the following year.

Central Valley Project (CVP) Operated by the U.S. Bureau of Reclamation, the CVP is a water storage and delivery system consisting of 20 dams and reservoirs (including Shasta, Folsom, and New Melones Reservoirs), 11 power plants, and 500 miles of major canals. CVP facilities reach some 400 miles from Redding to Bakersfield and deliver about 7 million acre-feet of water for agricultural, urban, and wildlife use.

cubic feet per second (cfs) A measure of the rate at which a river of stream is flowing. The flow is 1 cfs if a cubic foot (about 7.48 gallons) of water passes a specific point in 1 second. A flow of 1 cubic foot per second for a day is approximately 2 acre-feet.

Delta exports Water transferred ("exported") to areas south of the Delta through the Harvey O. Banks Pumping Plant (SWP) and the C. W. "Bill" Jones Pumping Plant (CVP). The SWP's Delta exports are the primary component of total SWP deliveries.

Delta inflow The combined total of water flowing into the Delta from the Sacramento River, San Joaquin River, and other rivers and waterways.

exceedence curve For the SWP, a chart showing SWP delivery probability (especially for Table A water)—specifically, the likelihood that SWP contractors will receive a certain volume of water under current or future conditions.

existing-conditions scenario For the SWP delivery reliability reports, the results of modeling for SWP Delta exports or deliveries for the year the report was written.

future-conditions scenario For the SWP delivery reliability reports, the results of modeling for SWP Delta exports or SWP deliveries for 20 years into the future.

incidental take permit A permit issued by the U.S. Fish and Wildlife Service, under Section 10 of the federal Endangered Species Act, to private nonfederal entities undertaking otherwise lawful projects that might result in the "take" of an endangered or threatened species. In California, take may be authorized under Section 2081 of the California Fish and Game Code through issuance of either an incidental take permit or a consistency determination. The California Department of Fish and Game is authorized to accept a federal biological opinion as the take authorization for a State-listed species when a species is listed under both the federal and California Endangered Species Acts.

riparian water rights Water rights that apply to lands traversed by or bordering on a natural watercourse. No permit is required to use this water, which must be used on riparian (adjacent) land and cannot be stored for later use.

State Water Project (SWP) Operated by DWR, a water storage and delivery system of 33 storage facilities, 701 miles of open canals and pipelines, five hydroelectric power plants, and 20 pumping plants that extends for more than 600 miles in California. Its main purpose is to store and distribute water to 29 urban and agricultural water suppliers in Northern California, the San Francisco Bay Area, the San Joaquin Valley, the Central Coast, and Southern California. The SWP provides supplemental water to approximately 25 million Californians (two-thirds of California's population) and about 750,000 acres of irrigated farmland. Water deliveries have ranged from 1.4 million acre-feet in a dry year to more than 4.0 million acre-feet in a wet year.

SWP contractors Twenty-nine entities that receive water for agricultural or municipal and industrial uses through the SWP. Each contractor has executed a long-term water supply contract with DWR. Also sometimes referred to as "State Water Contractors."

Table A water (Table A amounts) The maximum amount of SWP water that the State agreed to make available to an SWP contractor for delivery during the year. Table A amounts determine the maximum water a contractor may request each year from DWR. The State and SWP contractors also use Table A amounts to serve as a basis for allocation of some SWP costs among the contractors.

turnback pool water Allocated water that individual SWP contractors may offer early in the year for other SWP contractors to buy later at a set price.

urban water supplier As defined by the California Water Code, a public or private supplier that provides water for municipal use directly or indirectly to more than 3,000 customers or supplies more than 3,000 acre-feet of water in a year. This can be a water district that provides the water to local residents for use at home or work, or a contractor that distributes or sells water to that water district.

Water Rights Decision 1641 (D-1641) A regulatory decision issued by the State Water Resources Control Board in 1999 (updated in 2000) to implement the 1995 *Water Quality Control Plan for the San Francisco Bay/Sacramento–San Joaquin Delta*. D-1641 assigned primary responsibility for meeting many of the Delta's water quality objectives to the SWP and CVP, thus placing certain limits on SWP and CVP operations.

water year In reports on surface water supply, the period extending from October 1 through September 30 of the following calendar year. The water year refers to the September year. For example, October 1, 2010, through September 30, 2011 is the 2011 water year.

This page intentionally left blank.

References

2007 Working Group on California Earthquake Probabilities. 2008. *The Uniform California Earthquake Rupture Forecast, Version 2 (UCERF 2)*. U.S. Geological Survey Open-File Report 2007-1437 and California Geological Survey Special Report 203.

California Climate Change Center. 2009a (May). *Using Future Climate Projections to Support Water Resources Decision Making in California.* CEC-500-2009-052-F. Prepared by California Department of Water Resources (F. Chung, J. Anderson, S. Arora, M. Ejeta, J. Galef, T. Kadir, K. Kao, A. Olson, C. Quan, E. Reyes, M. Roos, S. Seneviratne, J. Wang, H. Yin, and N. Blomquist). Sacramento, CA.

———. 2009b (May). *The Impacts of Sea-Level Rise on the California Coast.* Final Paper. CEC-500-2009-024-F. Sacramento, CA. Prepared by the Pacific Institute, Oakland, CA.

California Department of Water Resources. 1995. *Sacramento–San Joaquin Delta Atlas.* Reprinted July 1995. Sacramento, CA.

2006 (July). *Progress on Incorporating Climate Change into Management of California's Water Resources.* Technical memorandum report. Bay-Delta Office, Sacramento, CA.

———. 2007 (April). *Delta Emergency Operations Plan Concept Paper.* Division of Flood Management. Sacramento, CA.

———. 2008 (October). *Managing an Uncertain Future: Climate Change Adaptation Strategies for California's Water.* Sacramento, CA.

———. 2009a. *California Drought, An Update: June 2009.* 2009 Mid-Year Report. Sacramento, CA.

———. 2009b. *California Water Plan Update 2009.* Volume 1—The Strategic Plan. Strategic Water Planning Branch. Sacramento, CA.

———. 2011a. Modeling Description of the Sacramento–San Joaquin Delta and Suisun Marsh Constraints on the SWP/CVP Water System. By A. Munevar. Available:

http://modeling.water.ca.gov/hydro/model/calsim-doc/Operational-Criteria/Delta/readme-delta-final.html. Accessed December 29, 2011.

———. 2011b (June). *Delta Risk Management Strategy: Phase 2 Report.* Delta Levees and Environmental Engineering Branch, FloodSAFE Environmental Stewardship and Statewide Resources Office. Sacramento, CA. Prepared by URS Corporation and Jack R. Benjamin & Associates, Inc.

California Department of Water Resources and California Department of Fish and Game. 2008 (January). *Risks and Options to Reduce Risks to Fishery and Water Supply Uses of the Sacramento/San Joaquin Delta. A Report Pursuant to Requirements of Assembly Bill 1200, Laird.* Sacramento, CA.

DWR. *See* California Department of Water Resources.

DWR and DFG. *See* California Department of Water Resources and California Department of Fish and Game.

Reclamation. *See* U.S. Bureau of Reclamation.

State Water Resources Control Board. 1995 (May). *Water Quality Control Plan for the San Francisco Bay/Sacramento–San Joaquin Estuary.* 95-1WR. Sacramento, CA.

SWRCB. *See* State Water Resources Control Board.

U.S. Bureau of Reclamation. 2009 (June 25). "Federal Perspective: Central Valley Project and Water Management in California." Testimony by Ron Milligan, Operations Manager, Central Valley Project, before the Little Hoover Commission hearing on Water Governance, State Capitol Room 437, Sacramento, CA.

Working Group. *See* 2007 Working Group on California Earthquake Probabilities.





Appendix A

Historical SWP Delivery Tables for 2001–2010

The State Water Project (SWP) contracts define several types of SWP water available for delivery to contractors under specific circumstances: Table A water, Article 21 water, turnback pool water, and carryover water. (See the glossary for definitions of these terms; Chapter 3 describes each type of SWP water in greater detail.) Many SWP contractors frequently use Article 21, turnback pool, and carryover water to increase or decrease the amount of water available to them under SWP Table A.

The Sacramento River Index, previously referred to as the “4 River Index” or “4 Basin Index,” is the sum of the unimpaired runoff of four rivers: the Sacramento River above Bend Bridge near Red Bluff, Feather River inflow to Lake Oroville Reservoir, Yuba River at Smartville, and American River inflow to Folsom Lake. The five water year types used in the Sacramento River Index are as follows:

Sacramento River Index	Water Year Type
1	Wet
2	Above Normal
3	Below Normal
4	Dry
5	Critical

Tables A-1 through A-10 list annual historical deliveries by SWP water type for each contractor for 2001 through 2010. The Sacramento River Index and water year type are presented along with the delivery results for each year. Similar delivery tables are presented for years 1999–2008 in the *State Water Project Delivery Reliability Report 2009*. SWP contractors are listed in Tables A-1 through A-10 by location, as follows:

- *Feather River Area:* Butte County, Yuba City, and Plumas County Flood Control and Water Conservation District (FCWCD)
- *North Bay Area:* Napa County FCWCD and Solano County Water Agency (WA)
- *South Bay Area:* Alameda County FCWCD, Zone 7; Alameda County Water District (WD); and Santa Clara Valley WD
- *San Joaquin Valley Area:* Dudley Ridge WD, Empire West Side Irrigation District (ID), Kern County WA, Kings County, Oak Flat WD, and Tulare Lake Basin Water Storage District (WSD)

- *Central Coastal Area:* San Luis Obispo County FCWCD and Santa Barbara County FCWCD
- *Southern California Area:* Antelope Valley–East Kern WA, Castaic Lake WA, Coachella Valley WD, Crestline–Lake Arrowhead WA, Desert Water Agency, Littlerock Creek ID, Metropolitan WD of Southern California, Mojave WA, Palmdale WD, San Bernardino Valley Municipal Water District (MWD), San Gabriel Valley MWD, San Gorgonio Pass WA, and Ventura County Watershed Protection District (WPD)

Table A-1. Historical State Water Project Deliveries, 2001
Sacramento River Index = 4, Water Year Type = Dry

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

* Table A = State Water Project Analysis Office current-year deliveries + next year's Article 14B carryover water

** Total deliveries from the Delta = Total SWP deliveries – Feather River Service Area deliveries (Butte County, Yuba City, and Plumas County Flood Control and Water Conservation District)

Table A-2. Historical State Water Project Deliveries, 2002
Sacramento River Index = 4, Water Year Type = Dry

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

* Table A = State Water Project Analysis Office current-year deliveries + next year's Article 14B carryover water

** Total deliveries from the Delta = Total SWP deliveries – Feather River Service Area deliveries (Butte County, Yuba City, and Plumas County Flood Control and Water Conservation District)

Table A-3. Historical State Water Project Deliveries, 2003 Sacramento River Index = 2, Water Year Type = Above Normal						
Contractor Location	SWP Contractor	SWP Water Type Delivered (acre-feet)				Total SWP Deliveries (acre-feet)
		Table A*	Article 21	Carryover	Turnback	
Feather River Area	Butte County	551	–	–	–	551
	Yuba City	1,324	–	–	–	1,324
	Plumas County FCWCD	–	–	–	–	–
North Bay Area	Napa County FCWCD	6,026	376	1,055	180	7,637
	Solano County WA	25,135	2,280	1,918	–	29,333
South Bay Area	Alameda County FCWCD, Zone 7	30,695	–	13,099	656	44,450
	Alameda County WD	31,086	–	5,150	354	36,590
	Santa Clara Valley WD	90,620	936	14,104	841	106,501
San Joaquin Valley Area	Dudley Ridge WD	49,723	1,928	1,452	482	53,585
	Empire West Side ID	1,074	175	187	–	1,436
	Kern County WA	841,697	27,891	22,380	8,419	900,387
	Kings County	3,600	58	–	34	3,692
	Oak Flat WD	4,059	19	140	48	4,266
	Tulare Lake Basin WSD	94,376	6,243	4,284	938	105,841
Central Coastal Area	San Luis Obispo County FCWCD	4,417	36	–	–	4,453
	Santa Barbara County FCWCD	24,312	339	2,274	43	26,968
Southern California Area	Antelope Valley–East Kern WA	52,730	–	7,049	250	60,029
	Castaic Lake WA (+Rch 31A, 5 & 7)	49,895	991	4,760	90	55,736
	Coachella Valley WD	14,045	204	–	194	14,443
	Crestline–Lake Arrowhead WA	1,563	–	–	–	1,563
	Desert WA	23,168	330	–	321	23,819
	Littlerock Creek ID	–	–	–	–	–
	Metropolitan WD of Southern California	1,550,356	17,622	134,845	16,920	1,719,743
	Mojave WA	10,907	–	3,528	–	14,435
	Palmdale WD	9,701	–	1,846	–	11,547
	San Bernardino Valley MWD	25,371	200	1,844	–	27,415
	San Gabriel Valley MWD	13,034	200	–	–	13,234
	San Gorgonio Pass WA	116	–	–	–	116
	Ventura County WPD	5,000	–	–	–	5,000
Total SWP Deliveries		**2,964,581**	**59,828**	**219,915**	**29,770**	**3,274,094**
Total Deliveries from the Delta**		**2,962,706**	**59,828**	**219,915**	**29,770**	**3,272,219**

* Table A = State Water Project Analysis Office current-year deliveries + next year's Article 14B carryover water

** Total deliveries from the Delta = Total SWP deliveries – Feather River Service Area deliveries (Butte County, Yuba City, and Plumas County Flood Control and Water Conservation District)

Table A-4. Historical State Water Project Deliveries, 2004
Sacramento River Index = 3, Water Year Type = Below Normal

Contractor Location	SWP Contractor	SWP Water Type Delivered (acre-feet)				Total SWP Deliveries (acre-feet)
		Table A*	Article 21	Carryover	Turnback	
Feather River Area	Butte County	1,440	–	–	–	1,440
	Yuba City	1,434	–	–	–	1,434
	Plumas County FCWCD	–	–	–	–	–
North Bay Area	Napa County FCWCD	5,030	1,450	1,602	52	8,134
	Solano County WA	17,991	7,787	47	–	25,825
South Bay Area	Alameda County FCWCD, Zone 7	39,898	–	11,466	–	51,364
	Alameda County WD	20,956	–	6,714	214	27,884
	Santa Clara Valley WD	52,867	2,983	–	508	56,358
San Joaquin Valley Area	Dudley Ridge WD	36,377	7,393	2,185	291	46,246
	Empire West Side ID	1,310	626	1,626	–	3,562
	Kern County WA	640,190	86,513	40,120	5,075	771,898
	Kings County	5,850	3,157	–	46	9,053
	Oak Flat WD	4,324	–	276	29	4,629
	Tulare Lake Basin WSD	58,575	15,299	5,638	489	80,001
Central Coastal Area	San Luis Obispo County FCWCD	4,096	69	–	–	4,165
	Santa Barbara County FCWCD	29,566	–	–	122	29,688
Southern California Area	Antelope Valley–East Kern WA	50,532	–	9,199	–	59,731
	Castaic Lake WA (+Rch 31A, 5 & 7)	46,358	1,618	35,785	–	83,761
	Coachella Valley WD	8,631	–	6,745	89	15,465
	Crestline–Lake Arrowhead WA	2,006	–	–	–	2,006
	Desert WA	9,966	–	11,122	102	21,190
	Littlerock Creek ID	–	–	–	–	–
	Metropolitan WD of Southern California	1,195,807	91,601	215,000	10,223	1,512,631
	Mojave WA	11,176	–	–	–	11,176
	Palmdale WD	10,549	–	1,613	–	12,162
	San Bernardino Valley MWD	35,522	–	20,631	–	56,153
	San Gabriel Valley MWD	15,600	–	–	–	15,600
	San Gorgonio Pass WA	841	–	–	–	841
	Ventura County WPD	5,250	–	–	–	5,250
	Total SWP Deliveries	**2,312,142**	**218,496**	**369,769**	**17,240**	**2,917,647**
	Total Deliveries from the Delta**	**2,309,268**	**218,496**	**369,769**	**17,240**	**2,914,773**

* Table A = State Water Project Analysis Office current-year deliveries + next year's Article 14B carryover water

** Total deliveries from the Delta = Total SWP deliveries – Feather River Service Area deliveries (Butte County, Yuba City, and Plumas County Flood Control and Water Conservation District)

Table A-5. Historical State Water Project Deliveries, 2005 Sacramento River Index = 2, Water Year Type = Above Normal						
Contractor Location	SWP Contractor	SWP Water Type Delivered (acre-feet)				Total SWP Deliveries (acre-feet)
		Table A*	Article 21	Carryover	Turnback	
Feather River Area	Butte County	527	–	–	–	527
	Yuba City	1,894	–	–	–	1,894
	Plumas County FCWCD	–	–	–	–	–
North Bay Area	Napa County FCWCD	5,322	606	1,741	–	7,669
	Solano County WA	24,515	10,421	83	–	35,019
South Bay Area	Alameda County FCWCD, Zone 7	38,388	–	7,849	275	46,512
	Alameda County WD	36,469	846	6,341	943	44,599
	Santa Clara Valley WD	89,476	6,298	11,899	342	108,015
San Joaquin Valley Area	Dudley Ridge WD	51,609	28,197	821	1,286	81,913
	Empire West Side ID	1,448	1,799	587	–	3,834
	Kern County WA	893,439	453,078	9,851	22,397	1,378,765
	Kings County	8,100	11,504	–	202	19,806
	Oak Flat WD	4,067	–	–	127	4,194
	Tulare Lake Basin WSD	86,604	47,267	3,973	2,158	140,002
Central Coastal Area	San Luis Obispo County FCWCD	4,006	245	–	–	4,251
	Santa Barbara County FCWCD	22,981	–	–	155	23,136
Southern California Area	Antelope Valley–East Kern WA	57,205	–	2,626	–	59,831
	Castaic Lake WA (+Rch 31A, 5 & 7)	54,303	2,451	2,702	–	59,456
	Coachella Valley WD	26,984	–	12,819	2,716	42,519
	Crestline–Lake Arrowhead WA	807	–	–	–	807
	Desert WA	33,168	–	14,799	1,122	49,089
	Littlerock Creek ID	–	–	–	–	–
	Metropolitan WD of Southern California**	1,269,291	168,300	106,032	6,530	1,550,153
	Mojave WA	10,360	–	1,201	–	11,561
	Palmdale WD	10,174	–	1,538	–	11,712
	San Bernardino Valley MWD	31,211	56	283	–	31,550
	San Gabriel Valley MWD	10,500	–	–	–	10,500
	San Gorgonio Pass WA	655	15	–	22	692
	Ventura County WPD	1,665	–	–	–	1,665
	Total SWP Deliveries	**2,775,168**	**731,083**	**185,145**	**38,275**	**3,729,671**
	Total Deliveries from the Delta***	**2,772,747**	**731,083**	**185,145**	**38,275**	**3,727,250**

* Table A = State Water Project Analysis Office current-year deliveries + Next year's Article 14B carryover water

** Metropolitan Water District of Southern California 2005 Table A deliveries have been updated to reflect the addition of Article 14B carryover water that was previously omitted.

*** Total deliveries from the Delta = Total SWP deliveries – Feather River Service Area deliveries (Butte County, Yuba City, and Plumas County Flood Control and Water Conservation District)

Table A-6. Historical State Water Project Deliveries, 2006
Sacramento River Index = 1, Water Year Type = Wet

Contractor Location	SWP Contractor	SWP Water Type Delivered (acre-feet)				Total SWP Deliveries (acre-feet)
		Table A*	Article 21	Carryover	Turnback	
Feather River Area	Butte County	468	–	–	–	468
	Yuba City	4,148	1,194	–	–	5,342
	Plumas County FCWCD	–	–	–	–	–
North Bay Area	Napa County FCWCD	7,312	300	172	–	7,784
	Solano County WA	12,070	18,195	390	–	30,655
South Bay Area	Alameda County FCWCD, Zone 7	50,785	–	2,252	491	53,528
	Alameda County WD	–	2,375	1,331	39,373	43,079
	Santa Clara Valley WD	47,344	26,769	524	–	74,637
San Joaquin Valley Area	Dudley Ridge WD	55,343	18,515	–	1,068	74,926
	Empire West Side ID	1,500	1,124	658	–	3,282
	Kern County WA	961,882	256,634	5,418	18,610	1,242,544
	Kings County	8,991	366	–	173	9,530
	Oak Flat WD	4,118	–	17	107	4,242
	Tulare Lake Basin WSD	48,361	59,424	–	1,787	109,572
Central Coastal Area	San Luis Obispo County FCWCD	3,382	827	–	–	4,209
	Santa Barbara County FCWCD	19,255	4,020	–	–	23,275
Southern California Area	Antelope Valley–East Kern WA	76,623	–	3,761	–	80,384
	Castaic Lake WA (+Rch 31A, 5 & 7)	56,758	2,089	3,905	–	62,752
	Coachella Valley WD	121,100	–	–	–	121,100
	Crestline–Lake Arrowhead WA	257	–	–	–	257
	Desert WA	50,000	–	–	–	50,000
	Littlerock Creek ID	–	–	–	–	–
	Metropolitan WD of Southern California	1,103,538	238,478	136,424	11,638	1,490,078
	Mojave WA	32,496	–	1,518	–	34,014
	Palmdale WD	10,374	1,653	335	130	12,492
	San Bernardino Valley MWD	31,902	–	3,427	–	35,329
	San Gabriel Valley MWD	13,524	–	–	–	13,524
	San Gorgonio Pass WA	4,262	–	–	–	4,262
	Ventura County WPD	1,850	–	–	–	1,850
	Total SWP Deliveries	**2,727,643**	**631,963**	**160,132**	**73,377**	**3,593,115**
	Total Deliveries from the Delta**	**2,723,027**	**630,769**	**160,132**	**73,377**	**3,587,305**

* Table A = State Water Project Analysis Office current-year deliveries + next year's Article 14B carryover water

** Total deliveries from the Delta = Total SWP deliveries – Feather River Service Area deliveries (Butte County, Yuba City, and Plumas County Flood Control and Water Conservation District)

Table A-7. Historical State Water Project Deliveries, 2007 Sacramento River Index = 4, Water Year Type = Dry						
Contractor Location	SWP Contractor	SWP Water Type Delivered (acre-feet)				Total SWP Deliveries (acre-feet)
		Table A*	Article 21	Carryover	Turnback	
Feather River Area	Butte County	956	–	–	–	956
	Yuba City	2,327	–	–	–	2,327
	Plumas County FCWCD	–	–	–	–	–
North Bay Area	Napa County FCWCD	6,362	3,597	998	–	10,957
	Solano County WA	14,892	8,217	1,822	–	24,931
South Bay Area	Alameda County FCWCD, Zone 7	32,972	912	2,895	378	37,157
	Alameda County WD	16,541	550	2,103	197	19,391
	Santa Clara Valley WD	38,812	4,840	8,161	469	52,282
San Joaquin Valley Area	Dudley Ridge WD	28,457	8,953	2,000	269	39,679
	Empire West Side ID	397	1,172	515	–	2,084
	Kern County WA	592,423	99,861	19,645	4,683	716,612
	Kings County	4,924	474	–	43	5,441
	Oak Flat WD	3,430	41	69	27	3,567
	Tulare Lake Basin WSD	57,272	12,902	16,459	450	87,083
Central Coastal Area	San Luis Obispo County FCWCD	3,752	24	–	–	3,776
	Santa Barbara County FCWCD	24,760	1,070	1,390	–	27,220
Southern California Area	Antelope Valley–East Kern WA	74,459	–	4,364	–	78,823
	Castaic Lake WA (+Rch 31A, 5 & 7)	44,974	–	4,216	–	49,190
	Coachella Valley WD	72,660	–	–	568	73,228
	Crestline–Lake Arrowhead WA	1,768	–	–	–	1,768
	Desert WA	30,000	–	–	234	30,234
	Littlerock Creek ID	1,380	–	–	–	1,380
	Metropolitan WD of Southern California	1,146,900	166,517	28,098	8,962	1,350,477
	Mojave WA	45,372	–	737	–	46,109
	Palmdale WD	12,780	843	985	100	14,708
	San Bernardino Valley MWD	57,116	–	–	–	57,116
	San Gabriel Valley MWD	10,000	–	–	–	10,000
	San Gorgonio Pass WA	4,009	–	–	–	4,009
	Ventura County WPD	3,000	–	–	–	3,000
	Total SWP Deliveries	**2,332,695**	**309,973**	**94,457**	**16,380**	**2,753,505**
	Total Deliveries from the Delta**	**2,329,412**	**309,973**	**94,457**	**16,380**	**2,750,222**

* Table A = State Water Project Analysis Office current-year deliveries + next year's Article 14B carryover water

** Total deliveries from the Delta = Total SWP deliveries – Feather River Service Area deliveries (Butte County, Yuba City, and Plumas County Flood Control and Water Conservation District)

Table A-8. Historical State Water Project Deliveries, 2008
Sacramento River Index = 5, Water Year Type = Critical

Contractor Location	SWP Contractor	SWP Water Type Delivered (acre-feet)				Total SWP Deliveries (acre-feet)
		Table A*	Article 21	Carryover	Turnback	
Feather River Area	Butte County	9,436	–	–	–	9,436
	Yuba City	1,923	–	–	–	1,923
	Plumas County FCWCD	243	–	–	–	243
North Bay Area	Napa County FCWCD	3,636	1,219	7,363	21	12,239
	Solano County WA	10,436	1,510	12,389	–	24,335
South Bay Area	Alameda County FCWCD, Zone 7	13,633	–	15,400	–	29,033
	Alameda County WD	4,206	–	8,659	37	12,902
	Santa Clara Valley WD	11,133	–	21,188	88	32,409
San Joaquin Valley Area	Dudley Ridge WD	12,260	–	5,949	51	18,260
	Empire West Side ID		–	915	–	915
	Kern County WA	271,636	–	6,815	883	279,334
	Kings County	3,187	–	–	8	3,195
	Oak Flat WD	1,929	–	–	5	1,934
	Tulare Lake Basin WSD	32,302	–	281	85	32,668
Central Coastal Area	San Luis Obispo County FCWCD	8,512	–	–	–	8,512
	Santa Barbara County FCWCD	11,311	–	2,532	40	13,883
Southern California Area	Antelope Valley–East Kern WA	31,082	–	10,381	125	41,588
	Castaic Lake WA (+Rch 31A, 5 & 7)	18,710	–	12,146	–	30,856
	Coachella Valley WD	42,385	–	–	107	42,492
	Crestline–Lake Arrowhead WA	1,159	–	689	–	1,848
	Desert WA	17,500	–	–	44	17,544
	Littlerock Creek ID	805	–	–	–	805
	Metropolitan WD of Southern California	654,304	–	–	1,689	655,993
	Mojave WA	26,288	–	108	–	26,396
	Palmdale WD	4,226	–	–	19	4,245
	San Bernardino Valley MWD	30,562	–	4,444	–	35,006
	San Gabriel Valley MWD	10,080	–	–	–	10,080
	San Gorgonio Pass WA	5,419	–	300	–	5,719
	Ventura County WPD	3,798	–	–	–	3,798
	Total SWP Deliveries	**1,242,101**	**2,729**	**109,559**	**3,202**	**1,357,591**
	Total Deliveries from the Delta**	**1,230,499**	**2,729**	**109,559**	**3,202**	**1,345,989**

* Table A = State Water Project Analysis Office current-year deliveries + next year's Article 14B carryover water

** Total deliveries from the Delta = Total SWP deliveries – Feather River Service Area deliveries (Butte County, Yuba City, and Plumas County Flood Control and Water Conservation District)

Table A-9. Historical State Water Project Deliveries, 2009
Sacramento River Index = 4, Water Year Type = Dry

Contractor Location	SWP Contractor	SWP Water Type Delivered (acre-feet)				Total SWP Deliveries (acre-feet)
		Table A*	Article 21	Carryover	Turnback	
Feather River Area	Butte County	581	–	–	–	581
	Yuba City	2,114	–	–	–	2,114
	Plumas County FCWCD	200	–	–	–	200
North Bay Area	Napa County FCWCD	2,723	1,588	4,475	13	8,799
	Solano County WA	8,618	4,444	3,123	–	16,185
South Bay Area	Alameda County FCWCD, Zone 7	12,093	–	14,584	–	26,677
	Alameda County WD	5,911	–	10,494	8	16,413
	Santa Clara Valley WD	9,188	–	23,867	54	33,109
San Joaquin Valley Area	Dudley Ridge WD	13,185	–	7,810	32	21,027
	Empire West Side ID	1,034	–	–	–	1,034
	Kern County WA	226,631	–	56,367	544	283,542
	Kings County	3,153	–	70	5	3,228
	Oak Flat WD	1,825	–	66	1	1,892
	Tulare Lake Basin WSD	35,160	–	1,271	52	36,483
Central Coastal Area	San Luis Obispo County FCWCD	3,799	–	–	–	3,799
	Santa Barbara County FCWCD	12,746	–	4,523	25	17,294
Southern California Area	Antelope Valley–East Kern WA	14,419	–	18,408	77	32,904
	Castaic Lake WA (+Rch 31A, 5 & 7)	14,858	–	9,529	52	24,439
	Coachella Valley WD	40,845	–	–	66	40,911
	Crestline–Lake Arrowhead WA	–	–	893	–	893
	Desert WA	16,865	–	–	27	16,892
	Littlerock Creek ID	–	–	–	–	–
	Metropolitan WD of Southern California	544,304	–	10,721	1,042	556,067
	Mojave WA	21,312	–	242	–	21,554
	Palmdale WD	12,095	–	3,229	–	15,324
	San Bernardino Valley MWD	26,785	–	9,348	–	36,133
	San Gabriel Valley MWD	11,516	–	–	–	11,516
	San Gorgonio Pass WA	5,612	–	480	–	6,092
	Ventura County WPD	3,890	–	–	–	3,890
	Total SWP Deliveries	**1,051,462**	**6,032**	**179,500**	**1,998**	**1,238,992**
	Total Deliveries from the Delta**	**1,048,567**	**6,032**	**179,500**	**1,998**	**1,236,097**

* Table A = State Water Project Analysis Office current-year deliveries + next year's Article 14B carryover water

** Total deliveries from the Delta = Total SWP deliveries – Feather River Service Area deliveries (Butte County, Yuba City, and Plumas County Flood Control and Water Conservation District)

Table A-10. Historical State Water Project Deliveries, 2010
Sacramento River Index = 3, Water Year Type = Below Normal

Contractor Location	SWP Contractor	SWP Water Type Delivered (acre-feet)				Total SWP Deliveries (acre-feet)
		Table A*	Article 21	Carryover	Turnback	
Feather River Area	Butte County	807	–	–	–	807
	Yuba City	2,331	–	–	–	2,331
	Plumas County FCWCD	243	–	–	–	243
North Bay Area	Napa County FCWCD	7,275	2,207	2,845	90	12,417
	Solano County WA	16,793	5,298	3,661	–	25,752
South Bay Area	Alameda County FCWCD, Zone 7	28,694	–	12,756	249	41,699
	Alameda County WD	11,668	–	10,889	14	22,571
	Santa Clara Valley WD	6,068	–	10,741	34	16,843
San Joaquin Valley Area	Dudley Ridge WD	15,833	–	9,752	156	25,741
	Empire West Side ID	380	–	–	–	380
	Kern County WA	375,426	–	55,419	3,044	433,889
	Kings County	4,094	–	522	29	4,645
	Oak Flat WD	2,412	–	455	18	2,885
	Tulare Lake Basin WSD	35,985	–	3,199	275	39,459
Central Coastal Area	San Luis Obispo County FCWCD	3,480	–	277	–	3,757
	Santa Barbara County FCWCD	8,640	–	7,134	140	15,914
Southern California Area	Antelope Valley–East Kern WA	36,462	–	20,813	438	57,713
	Castaic Lake WA (+Rch 31A, 5 & 7)	37,054	–	14,501	295	51,850
	Coachella Valley WD	69,175	–	7,595	429	77,199
	Crestline–Lake Arrowhead WA	357	–	–	–	357
	Desert WA	27,875	–	3,135	173	31,183
	Littlerock Creek ID		–	–	–	–
	Metropolitan WD of Southern California	817,765	–	67,783	5,922	891,470
	Mojave WA	35,241	–	20	–	35,261
	Palmdale WD	5,585	–	5,325	59	10,969
	San Bernardino Valley MWD	37,733	–	11,273	–	49,006
	San Gabriel Valley MWD	19,180	–	–	–	19,180
	San Gorgonio Pass WA	6,626	–	–	6	6,632
	Ventura County WPD	4,075	–	–	–	4,075
	Total SWP Deliveries	**1,617,257**	**7,505**	**248,095**	**11,371**	**1,884,228**
	Total Deliveries from the Delta**	**1,613,876**	**7,505**	**248,095**	**11,371**	**1,880,847**

* Table A = State Water Project Analysis Office current-year deliveries + next year's Article 14B carryover water

** Total deliveries from the Delta = Total SWP deliveries – Feather River Service Area deliveries (Butte County, Yuba City, and Plumas County Flood Control and Water Conservation District)

This page intentionally left blank.

Appendix B

Comment Letters on the Draft Report and the Department's Responses

This page intentionally left blank.

THE METROPOLITAN WATER DISTRICT
OF SOUTHERN CALIFORNIA

Office of the General Manager

March 12, 2012

Ms. Cynthia Pierson
California Department of Water Resources
SWP Delivery Reliability Report – Attn: Cynthia Pierson
P.O. Box 942836
Sacramento, CA 94236-0001

Dear Ms. Pierson:

State Water Project Delivery Reliability Report 2011 – January 2012 Draft

The Metropolitan Water District of Southern California (Metropolitan) has reviewed the Department of Water Resources (Department) January 2012 draft of the State Water Project (SWP) Delivery Reliability Report 2011 (DRR) and offers the following comments and observations.

Metropolitan understands the Department's desire to produce a public outreach document with the intent to educate Californians about the SWP and its operations. However, we do not agree that this should be the purpose of the DRR. The preparation of this report should be to satisfy the obligation set forth in the 2003 Monterey Settlement (Settlement) between DWR, the State Water Contractors (SWC) and the Monterey Amendment Plaintiffs. The Settlement requires a report on the delivery capability of the SWP facilities to be distributed biannually to all SWP contractors, city and county planning departments, and regional and metropolitan planning departments in the SWP's service area. Metropolitan suggests that the Department refocus the report to provide a summary of the technical analysis including the assumptions used in the analysis and a description of the results. Similar to previous versions of the DRR, the report should focus on the technical needs of the SWC and regional planning agencies for information on the reliability of the SWP. This report should not be used as a larger public outreach document.

Metropolitan believes that an education can be provided to readers of the DRR while remaining true to its original intent. To that end, we encourage the Department to reconsider the use of the term "Delta exports", which may mislead the reader. This term is used throughout the report in a fashion that promotes the notion that we are exporting a native supply out of the Delta. Rather, these supplies were developed through SWP Conservation Facilities and SWP water rights and represent a small percentage of the total flows passing through the Delta. We would like to see the report be clear on the fact that the water diverted is a SWP developed supply.

700 N. Alameda Street, Los Angeles, California 90012 • Mailing Address: Box 54153, Los Angeles, California 90054-0153 • Telephone (213) 217-6000

Metropolitan acknowledges the difficulties in preparing a report of this magnitude particularly with the variability in hydrology, regulatory restrictions and climate change uncertainties. Metropolitan continues to offer its assistance with the development of this report. We encourage the Department to engage not only Metropolitan but other SWP contractors early in the preparation of the document. We believe a more collaborative process will facilitate feedback from the end users resulting in an improved document.

Very truly yours,

Deven N. Upadhyay
Manager, Water Resource Management

DJP:jc
o:\a\s\c\2012\DJP_SWPDel Rel comment.doc

Mr. Mark Cowin
Director, California Department of Water Resources
P.O. Box 942836, Room 1115-1
Sacramento, CA 94236-0001

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

Mr. Terry Erlewine
General Manager
State Water Contractors
1121 L Street, Suite 1050
Sacramento, CA 95814

STATE OF CALIFORNIA – CALIFORNIA NATURAL RESOURCES AGENCY **EDMUND G. BROWN JR.**, *Governor*

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

June 25, 2012

Mr. Deven N. Upadhyay
Manager, Water Resources Management
The Metropolitan Water District of Southern California
PO Box 54153
Los Angeles, California 90054-0153

Dear Mr. Upadhyay:

This letter responds to your letter dated March 12, 2012 commenting on the draft State Water Project Delivery Reliability Report (2011). We appreciate your review and subsequent comments to the draft report.

Your first comment is regarding the format of the report. Metropolitan would like the Department of Water Resources to focus on the technical needs of the State Water Contractors and regional planning agencies for information on the reliability of the State Water Project (SWP) and not plan to use the report as a larger public outreach document.

The reformatting of the Delivery Reliability Report is intended to make the information more understandable to the public. The Monterey Settlement (2003) requires a report covering this subject to be published every two years and that the information contained in the report be readily understandable by the public. The previous versions of the report focus on estimated amounts for Table A deliveries and other categories of deliveries defined in the SWP water delivery contracts. We agree that this is valuable information for our contractors and planning entities within the SWP service area however, it is not readily understandable to the public. Our intent in reformatting the report is to meet the needs of both audiences. The main report is intended for the public audience and the accompanying technical addendum intended for State Water Contractors and regional planning agencies. The technical addendum includes descriptions of the analyses, the results, and the breakdown of the information for each contractor.

Your second comment is regarding the use of the term "Delta exports" for the water pumped from the Delta by the SWP. Your observation is that the term is used in a manner that may mislead the reader by promoting the notion that the SWP exports a "native supply" from the Delta rather than one developed through the SWP conservation facilities and water rights. The term "Delta exports" is one that is commonly used in Department reports. It refers to the water that is released from Oroville Reservoir and transferred across the Delta as well as other flows that enter the Delta and are available to the SWP while meeting the relevant water rights' requirements and other export regulations. Chapters 2 through 4 are intended to inform the reader about the history, facilities and requirements for operation of the SWP. It is our hope that this information will help to avoid any potential misinterpretation by the reader regarding what is meant by the term "Delta exports".

The final 2011 State Water Project Delivery Reliability Report is nearing completion and is expected to be available next month. If you would like to discuss your concerns further, please contact me at (916) 653-1099 or kkelly@water.ca.gov.

Sincerely,

Katherine Kelly

Katherine F. Kelly, Chief
Bay-Delta Office

Mojave Water Agency

13846 Conference Center Drive ♦ Apple Valley, California 92307
Phone (760) 946-7000 ♦ Fax (760) 240-2642 ♦ www.mojavewater.org

VIA ELECTRONIC MAIL

March 12, 2012

California Department of Water Resources
SWP Delivery Reliability Report- Attn: Cynthia Pierson
P.O. Box 942836
Sacramento, CA 94236-0001

RE: Comments on the State Water Project Draft Delivery Reliability Report 2011

Dear Ms. Pierson:

The Mojave Water Agency has reviewed the SWP Draft Delivery Reliability Report 2011 ("2011 DRR") and offers these comments. In general, we appreciated the format and information included in the 2009 DRR and would like to see the same level of detail and information presented in the 2011 DRR. Please consider the following comments:

1. Individual Contractor Modeling Results: We appreciate the inclusion of individual contractor modeling outputs in the Technical Addendum.
2. Reliability Numbers: In addition to the charts in the 2011 DRR (figures 6-5 thru 6-9), the body of the report should include SWP reliability percentages, either in the text or in tables, as was done in the 2009 DRR. This should be done for current and future conditions for the long-term average, drought cycles, and wet cycles (example: Tables 6.1 thru 6.4 in the 2009 DRR). Average-year and dry-year numbers are critical information for urban water suppliers to include in their Urban Water Management Plans, which are used to demonstrate water supply sufficiency for their service areas.
3. Effects of Climate Change: We appreciate the inclusion of modeling results comparing future SWP deliveries with and without the effects of climate change; this will be of great help to agencies preparing climate change evaluations for water supply planning purposes.
4. Factors Affecting Reliability: Chapter 4 describes a number of factors that have reduced or have the potential to reduce future water supply reliability. The chapter should also "disclose" that some future actions may actually increase future reliability:
   a. The recent court decisions overturning Federal Biological Opinions (BO's) were mentioned; but it should be mentioned that implementation of future BO's may result in less restriction on delta exports.
   b. The Bay Delta Conservation Plan (BDCP) was described briefly, but it should also indicate that the conveyance piece of the BDCP will likely result in increased reliability.

Thank you for your consideration of our comments.

Sincerely,

Kirby Brill
General Manager

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

May 23, 2012

Kirby Brill
General Manager
Mojave Water Agency
13846 Conference Center Drive
Apple Valley, California 92307

Dear Mr. Brill,

This letter is in response to your letter dated March 12, 2012 providing the comments of the Mojave Water Agency for the Draft 2011 SWP Delivery Reliability Report. Our responses to your four comments are attached.

I appreciate you and your staff's comments. If you or your staff wish to discuss this report further, please contact me at (916) 653-1099 or kkelly@water.ca.gov. For specific questions regarding the analyses used for the report, please contact Francis Chung at (916) 653-5924.

Sincerely,

Katherine Kelly

Katherine F. Kelly, Chief
Bay-Delta Office

Attachment:

Attachment

The following responses are to the comments provided in the March 12, 2012 letter from the Mojave Water Agency. The comments are shown in italics.

1. *<u>Individual Contractor Modeling Results</u>: We appreciate the inclusion of individual contractor modeling outputs in the Technical Addendum.*

   Thank you. We strive to make the Delivery Reliability Report as informative and useful as possible.

2. *<u>Reliability Numbers</u>: In addition to the charts in the 2011 DRR (figures 6-5 thru 6-9), the body of the report should include SWP reliability percentages, either in the text or in tables, as was done in the 2009 DRR. This should be done for current and future conditions for the long-term average, drought cycles, and wet cycles (example: Tables 6.1 thru 6.4 in the 2009 DRR). Average-year and dry-year numbers are critical information for urban water suppliers to include in their Urban Water Management Plans, which are used to demonstrate water supply sufficiency for their service areas.*

   Tables 6-3, 6-4, 7-2, and 7-3 have been added to the report to include this information.

3. *Effects of Climate Change: We appreciate the inclusion of modeling results comparing future SWP deliveries with and without the effects of climate change; this will be of great help to agencies preparing climate change evaluations for water supply planning purposes.*

   Thank you. We are glad you found this information beneficial.

4. *Factors Affecting Reliability: Chapter 4 describes a number of factors that have reduced or have the potential to reduce future water supply reliability. The chapter should also "disclose" that some future actions may actually increase future reliability:*
   a. *The recent court decision overturning Federal Biological Opinions (BO's) were mentioned; but it should be mentioned that implementation of future BO's may result in less restriction on Delta exports.*
   b. *The Bay Delta Conservation Plan (BDCP) was described briefly, but it should also indicate that the conveyance piece of the BDCP will likely result in increased reliability.*

   We appreciate your suggestion. However, we feel it is premature to discuss the effects of potential future BOs or BDCP alternatives. This is something that we can keep in mind and discuss further as we begin to develop the 2013 SWP Delivery Reliability Report.

March 12, 2012

California Department of Water Resources
SWP Delivery Reliability Report-Attn: Cynthia Pierson
P.O. Box 942836
Sacramento, CA 94236-0001

Comments on 2011 SWP Draft Delivery Reliability Report

Dear Ms. Pierson:

The State Water Contractors (SWC) has reviewed the 2011 SWP Draft Delivery Reliability Report and offers these comments. The SWC are generally concerned about the level of detail in the presentation. Additionally, the SWC has also identified numerous specific editorial changes for your consideration.

The SWC are interested in discussing our concerns with DWR, primarily in relation to the forthcoming 2013 SWP Reliability Report. If you have any questions about our concerns or specific comments, please contact me at (916) 447-7357.

Sincerely,

Terry L. Erlewine
General Manager

Attachment

State Water Contractors
Specific Comments on DWR's 2011 State Water Project Delivery Reliability Report

Figure 2-2. This figure shows only inflows and outflows to the Delta, and does not provide information on the magnitude of total flows in the watershed or total outflow. A graph similar to that prepared for the Delta Vision that places the total disposition of water supply into context would be helpful.

Page 13. Discussion of how operations are coordinated with the CVP should reference the Coordinated Operations Agreement, which is the basis for that coordination.

Page 23. There is discussion of how individual SWP contractors manage their water supplies annually on the basis of available water supply. That kind of annual information is not the data that is contained in the Delivery Reliability Report and is provided separately by DWR's Operations Control Office. The discussion here reads as though the Delivery Reliability Report provides that information.

Page 27. The discussion of the status of the 2008 and 2009 Biological Opinions is not very informative. This discussion should expand briefly on Judge Wanger's opinion that the current BOs are BOs are "arbitrary, capricious and unlawful" and are currently being redone. The discussion should also note that a preliminary injunction was issued enjoining implementation of the Fall X2 action of the 2008 Delta Smelt Biological Opinion. Additionally, DWR and other plaintiffs in the case have the option to file actions challenging provisions of the Biological Opinions on a continuing basis until new BOs are developed.

Chapter 5. The SWC question that there is any need for this chapter in this report as this goes beyond the issue of delivery reliability. If DWR wants to report on the topic of exports separately, it should do so in a separate report to meet whatever purpose is identified. If DWR insists of having a chapter on exports, it should be moved to later in the report, after Chapters 6 and 7, which identify the basis for the studies reported on in the export chapter.

Page 37. The statement is made that Delta exports are the only SWP water supply source for 24 of the 29 SWP contractors. In fact, local runoff occasionally provides significant quantities of water supply in some wet years.

Page 38. The reference to "Upper Feather River Area contractors" should drop the term "Upper" and refer simply to the "Feather River contractors." The City of Yuba City is located on the lower Feather River.

Page 38. The discussion of water types is incomplete and confusing. It should either be expanded or dropped. Additionally, the word "surplus" should not be used in relation to Article 21 Water. Surplus water has a distinct meaning under the SWP Water Supply Contracts that is different than Article 21 Water

Figure 5-2. This graph would be better presented as a line graph than as a bar graph.

Page 41. The discussion presents results on existing and future conditions, without describing those conditions. This discussion would be enhanced if the entire Chapter 5 was included after Chapters 6 & 7, which are where the existing and future conditions are described.

Page 44. There is discussion of differences between the 2009 and 2011 Delivery Reliability Report that are not really meaningful and are totally within the margin of error for the modeling analysis. Rather than show repeated figures portraying these meaningless differences between the two reports, it would be preferable to abbreviate the text and figures and include a high level statement that the two reports are essentially identical.

Page 48. The discussion of the basis for local demands changing highlights water conservation as the only specific example of those changes. A much more important factor would be local management (i.e., local storage) within the service area.

Page 48. There is a reference to Kern Wet Year as the basis for variations in Article 21 Water demands, but no explanation of why that would be a factor. It would be useful to state that Kern River inflows are a major local water supply variable in Kern County Water Agency, which is the second largest SWP contractor and possesses significant local groundwater recharge potential.

Pages 51-53. As pointed out earlier, there is extensive discussion and numerous figures are presented to show the differences between the 2009 and 2011 Delivery Reliability Reports, which are essentially not meaningful and within the margin of error of the studies. Rather than included repetitive slides showing the same information, this section should be substantially reduced. In fact, the summary of results presented on Page 57 would suffice for all the presentation starting on page 51 and continuing to Page 57.

Page 57. In discussing the Dry year deliveries of Article 21 Water, there is no indication of the location of those deliveries. Given regulatory restrictions in place, it is likely that all the Article 21 Water Deliveries are made to the SWP contractors located north of the Delta. If so, that should be stated. Otherwise, the reader is left with the impression that Article 21 Water might be available for South of the Delta contractors.

Page 61. There is a reference to 4,133 taf/year as the "maximum Delta SWP Table A." The term Delta should be dropped and the reference should be only to "maximum SWP Table A."

Pages 62-68. Same comment as for Chapter 6. The discussion of differences between essentially identical modeling results is too long and should be truncated. The summary of results starting at page 68 could suffice for this entire discussion.

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

May 25, 2012

Terry L. Erlewine
General Manager
State Water Contractors
1121 L Street, Suite 1050
Sacramento, California 95814-3944

Dear Mr. Erlewine,

This letter is in response to your letter dated March 12, 2012 providing the comments of the State Water Contractors. I appreciate you and your members taking the time to review the Draft 2011 SWP Delivery Reliability Report and providing feedback. Our responses to your comments are attached.

If you or your staff wish to discuss this report further, please contact me at (916) 653-1099 or kkelly@water.ca.gov. For specific questions regarding the analyses used for the report, please contact Francis Chung at (916) 653-5924.

Sincerely,

Katherine Kelly

Katherine F. Kelly, Chief
Bay-Delta Office

Attachment:

Attachment

The following responses are to the comments provided in the March 12, 2012 letter from the State Water Contractors. The comments are shown in italics.

Figure 2-2. This figure shows only inflows and outflows to the Delta, and does not provide information on the magnitude of total flows in the watershed or total outflow. A graph similar to that prepared for the Delta Vision that places the total disposition of water supply into context would be helpful.

> We have updated this figure to include a more thorough mass balance of the Delta.

Page 13. Discussion of how operations are coordinated with the CVP should reference the Coordinated Operation Agreement, which is the basis for that coordination.

> We have updated the text on page 13 to mention the Coordinated Operation Agreement with language similar to that used in the sidebar on page 14 of the report.

Page 23. There is discussion of how individual SWP contractors manage their water supplies annually on the basis of available water supply. That kind of annual information is <u>not</u> the data that is contained in the Delivery Reliability Report and is provided separately by DWR's Operations Control Office. The discussion here reads as though the Delivery Reliability Report provides that information.

> We have updated the language on page 23 to clarify the type of information that can be found in the SWP Delivery Reliability Report.

Page 27. The discussion of the status of the 2008 and 2009 Biological Opinions is not very informative. This discussion should expand briefly on Judge Wanger's opinion that the current BOs are "arbitrary, capricious and unlawful" and are currently being redone. The discussion should also note that a preliminary injunction was issued enjoining implementation of Fall X2 action of the 2008 Delta Smelt Biological Opinion. Additionally, DWR and other plaintiffs in the case have option to file actions challenging provisions of the Biological Opinions on a continuing basis until new BOs are developed.

> Staff from the Bay-Delta Office coordinated with DWR's Office of the Chief Counsel on this section and they felt that this section should be a factual summary of the assumptions and criteria used to operate the projects. As a result, discussion of the related litigation is kept to a minimum.

Chapter 5. The SWC question that there is any need for this chapter in this report as this goes beyond the issue of delivery reliability. If DWR wants to report on the topic of exports separately, it should do so in a separate report to meet whatever purpose is identified. If DWR insists of having a chapter on exports, it should be moved to later in the report, after Chapters 6 and 7, which identify the basis for the studies reported on in the export chapter.

We have placed the "Exports" chapter before the "Deliveries" chapters simply because the exports precede deliveries in operations. Reordering chapters would cause significant rewriting to maintain document flow. We prefer to leave the content intact for the current report but we also want to consider the points you have brought up regarding exports as we start to formulate ideas for content to be included in the 2013 SWP Delivery Reliability Report.

Page 37. The statement is made that Delta exports are the only SWP water supply source for 24 of the 29 SWP contractors. In fact, local runoff occasionally provides significant quantities of water supply in some wet years.

The language on page 37 has been modified to clarify that Delta exports are not the only source of SWP water for the contractors.

Page 38. The reference to "Upper Feather River Area contractors" should drop the term "Upper" and refer simply to the "Feather River contractors." The City of Yuba City is located on the lower Feather River.

We agree completely and have removed the term "upper" from the Feather River description throughout the report and technical addendum.

Page 38. The discussion of water types is incomplete and confusing. It should either be expanded or dropped. Additionally, the word "surplus" should not be used in relation to Article 21 Water. Surplus water has a distinct meaning under the SWP Water Supply Contracts that is different than Article 21 Water.

We have made some modifications to the discussion of water types so it will, hopefully, be more clear now. We have also taken out the word "surplus" when describing Article 21 deliveries, per your suggestion.

Figure 5-2. This graph would be better presented as a line graph than as a bar graph.

We feel that the current graph format is aesthetically more consistent with the report layout.

Page 41. The discussion presents results on existing and future conditions, without describing those conditions. This discussion would be enhanced if the entire Chapter 5 was included after Chapters 6 & 7, which are where the existing and future conditions are described.

We have added text to this section to direct the reader to chapters 6 and 7 for more information regarding the assumptions for modeling existing and future conditions.

Page 44. There is discussion of differences between the 2009 and 2011 Delivery Reliability Report that are not really meaningful and are totally within the margin of error for the modeling analysis. Rather than show repeated figures portraying these meaningless differences between the two reports, it would be preferable to abbreviate the text and figures and include a high level statement that the two reports are essentially identical.

We have condensed the discussion of differences between the 2009 and 2011 report and removed some figures. Here is a list of changes for Chapter 5:

- The discussion in *Average, Maximum, and Minimum Annual Delta Exports* on page 41 of the Draft has been reduced
- Figure 5-3 has been replaced with the new Table 5-1
- Percent changes in Table 5-3 (formerly Table 5-2) have been removed and the discussion of existing exports by water year type has been reduced
- Percent changes in Table 5-4 (formerly Table 5-3) have been removed and the discussion of future exports by water year type has been reduced
- Figures 5-5, 5-6 and 5-7 have been removed
- The discussion in *Likelihood of SWP Exports—Existing and Future Conditions* section has been reduced

Page 48. The discussion of the basis for local demands changing highlights water conservation as the only specific example of those changes. A much more important factor would be local management (i.e., local storage) within the service area.

We have updated this section per your suggestion.

Page 48. There is a reference to Kern Wet Year as the basis for variation in Article 21 Water demands, but no explanation of why that would be a factor. It would be useful to state that Kern River inflows are a major local water supply variable in Kern County Water Agency, which is the second largest SWP contractor and possesses significant local groundwater recharge potential.

We have updated this section per your suggestion.

Page 51-53. As pointed out earlier, there is extensive discussion and numerous figures are presented to show the differences between the 2009 and 2011 Delivery Reliability Reports, which are essentially not meaningful and within the margin of error of the studies. Rather than included repetitive slides showing the same information, this section should be substantially reduced. In fact, the summary of results presented on Page 57 would suffice for all the presentation starting on page 51 and continuing to Page 57.

We have condensed the discussion of differences between the 2009 and 2011 report and removed some figures. Here is a list of changes for Chapter 6:

- Figure 6-1 has been replaced with new Table 6-1
- Figure 6-5 has been replaced with new Table 6-2 and the discussion in the *SWP Table A Water Deliveries* section has been reduced.
- Figure 6-7 has been removed
- Figures 6-8 and 6-9 have been replaced with new Tables 6-3 and 6-4 and the discussion of Dry-Year and Wet-Year Table A deliveries has been reduced on Draft page 53
- The discussion of *SWP Article 21 Water Deliveries* on Draft page 55 has been reduced
- The discussion of Dry-Year and Wet-Year Article 21 deliveries has been reduced on Draft page 57 and Figures 6-12 and 6-13 have been replaced with new Tables 6-5 and 6-6
- The Summary of Results for existing conditions have been worked into the main chapter text

Page 57. In discussion the Dry year deliveries of Article 21 Water, there is no indication of the location of those deliveries. Given regulatory restrictions in place, it is likely that all the Article 21 Water Deliveries are made to the SWP contractors located north of the Delta. If so, that should be stated. Otherwise, the reader is left with the impression that Article 21 Water might be available for South of Delta contractors.

Most of the Article 21 deliveries shown in the report for Dry years are for contractors south of the Delta. It happens during a few months under these conditions:

1. There is a low allocation
2. San Luis is full
3. Banks has capacity for pumping
4. Delta is in surplus conditions

Page 61. There is a reference to 4,133 taf/year as the "maximum Delta SWP Table A." The term Delta should be dropped and the reference should be only to "maximum SWP Table A."

This is meant to clarify that the results being presented are specific to those contractors that rely on delivery of water from the Delta. If we used "maximum SWP Table A" the value would be 4,172 taf/year.

Page 62-68. Same comment as for Chapter 6. The discussion of differences between essentially identical modeling results is too long and should be truncated. The summary of results starting at page 68 could suffice for this entire discussion.

We have condensed the discussion of differences between the 2009 and 2011 report and removed some figures. Here is a list of changes for Chapter 7:

- Figure 7-1 has been replaced with new Table 7-1
- The discussion in *Future Deliveries of SWP Table A Water* on Draft page 62 has been reduced
- Figure 7-3 has been removed
- Figures 7-4 and 7-9 have been replaced with new Tables 7-2 and 7-3 and the discussion of Dry-Year and Wet-Year Table A deliveries has been reduced on Draft page 64
- The discussion of *SWP Article 21 Water Deliveries* starting on Draft page 64 has been reduced
- The discussion of Dry-Year and Wet-Year Article 21 deliveries starting on Draft page 66 has been reduced and Figures 7-8 and 7-9 have been replaced with new Tables 7-4 and 7-5

Exhibit B

to Comments on the Department of Water Resources Draft Environmental Impact Report for the Water Supply Contract Extension Project

The Delta Plan

Ensuring a reliable water supply for California, a healthy Delta ecosystem, and a place of enduring value

2013

Delta Stewardship Council

Contents

Appendices

Tables

Figures and Sidebars

Executive Summary

Chapter 1

Chapter 2

Chapter 3

Chapter 4

STATE OF CALIFORNIA

Edmund G. Brown, Jr., Governor

THE DELTA STEWARDSHIP COUNCIL

This document was prepared under the direction of

Council Members

Phil Isenberg, Chair
Randy Fiorini, Vice Chair
Frank C. Damrell
Gloria Gray
Patrick Johnston
Hank Nordhoff
Don Nottoli
Richard Roos-Collins (2010-11)
Felicia Marcus (2011-12)

Delta Stewardship Council Lead Scientist

Peter Goodwin
Cliff Dahm (2010)

Delta Stewardship Council Executive Team

Chris Knopp
Dan Ray
Chris Stevens
Cindy Messer
Rainer Hoenicke
Lauren Hastings
Keith Coolidge
Jessica Pearson
Joe Grindstaff (2010-12)
Terry McCauley (2010-11)
Curtis Miller (2010-12)
Sue Garrett-Dukes (2010)

by

Delta Stewardship Council Staff

Eric Alvarez
Dusty Boeger
Mark Bradley
Marina Brand
Lindsay Correa
Angela D'Ambrosio
Jessica Davenport
Martha Davis
Chris Enright
Aaron Farber (2011-12)
Sam Harader
Paul Isaacs
Martina Koller
Carl Lischeske
Marla Lynch
Elaine Martin
Katie Morrice
Anke Mueller-Solger
Eric Nichol
Jessica O'Connor
Livia Page
Robbin Rediger (2011-13)
Pat Rogers
John Ryan
Kevan Samsam
Christie Thomason
Jason Waggoner
Cindy Whitlock
Dan Moseley (2010-11)
Steve Blecker (2012)

assisted by

Legal Support Staff

Dan Siegel
Christie Vosburg
Ellen Garber
James Andrew
Gabriel Ross
Sarah Sigman
Tori Sundheim (Intern)
Janelle Krattiger (Intern)

Technical Support Staff

CH2M HILL
GreenInfo – Larry Orman
John Hart
John Kirlin
Bob Twiss
Thomas Newman
Alison Whipple
Daniel Oros
Robin Grossinger (San Francisco Estuary Institute)
Bill Foster
Jeff Witteborg

Executive Summary

This page intentionally left blank.

Executive Summary

The Sacramento-San Joaquin River Delta is the grand confluence of California's waters, the place where the state's largest rivers merge in a web of channels—and in a maze of controversy. The Delta is a zone where the wants of a modern society come into collision with each other and with the stubborn limitations of a natural system. In 2009, seeking an end to decades of conflict over water, the Legislature established the Delta Stewardship Council with a mandate to resolve long-standing issues. The first step toward that resolution is the document you have before you, the Delta Plan.

Though more than 50 miles inland from the Golden Gate, Delta waters rise and fall with ocean tides. The Delta is in fact the upstream, mostly freshwater portion of the San Francisco Estuary, the largest estuarine system on the West Coast of the Americas, and one of California's prime natural assets. It is a major stop on the Pacific Flyway and the portal through which important fish species, including anadromous Chinook salmon, pass on their way to and from their spawning grounds in the interior.

The system of waters in which the Delta is so central has changed dramatically since California became a state. Rivers have been dammed and aqueducts built. Natural flows and fluxes have been disrupted to support cities and make the Central Valley the fruit basket and salad bowl of the nation. Approximately half of the water that historically flowed into and through the Delta is now diverted for human use, never reaching the sea. Much of this diversion occurs at points upstream, before the rivers come down to the Delta; but the last and largest draws take place in the Delta itself. On the southeast edge of the region, near Byron, two sets of mighty pumps extract water for shipment as far south as San Diego. Two-thirds of California's people and 4.5 million acres of farmland receive some part of their water from the Delta.

The Delta landscape we know is itself the result of a great transformation, from a primeval wetland complex to an archipelago of diked islands, where soils that once grew vast thickets of tules now yield bountiful corn, alfalfa, tomatoes, and many other crops. The Delta is home to about 12,000 people on farms and in small historic communities, and to about half a million in the larger cities that are

pressing into the region from the fringe. More millions come to it for boating, fishing, hunting, bird watching, even windsurfing on its 700 miles of channels. Steeped in history, combining notes of the American heartland and of Holland, the Delta looks and feels like no other place in California. This is a land that people love.

It is not doing so well.

The very shape of the modern Delta is in danger. Farming of peat-rich ground like this always leads to oxidation, the literal vanishing of soil, and thus to subsidence. Many Delta islands now lie 15 feet or more below sea level and depend on aging dikes to prevent the water in adjacent channels from pouring in. Higher river flows in winter or spring, predicted results of climate change, will add to the pressure, and a great earthquake, sooner or later, will shake the region like a paint can on a mixer. Encroaching urbanization, meanwhile, puts more people and property on dangerous ground.

After years of slow decline, the condition of the Delta's watery ecosystem, as measured especially by the population of wild salmon and other native fishes, has gone critical. The list of causes begins, but does not end, with all those water withdrawals, a kind of tax that leaves the system in a condition of chronic drought. The specific, peculiar manner in which the last large gulps of water are withdrawn adds to the ecological cost. The continual introduction of alien aquatic species from around the world is altering the web of life, often at the expense of native and other valued species. Pollution from the vast and busy watershed does its share of harm.

Today, all those who depend on or value the Delta are, in a word, afraid. Delta residents face the possibility of floods from the east when the rivers flow strongly and of salinity intrusion from the west if they flow too feebly. Fishermen, both commercial and recreational, fret about the future of salmon and other species. Water suppliers that receive water from the Delta find those supplies insecure, subject to interruption by weather vagaries, levee failures, or pumping restrictions imposed in the desperate attempt to stem the decline of fish.

Steeped in history, combining notes of the American heartland and of Holland, the Delta looks and feels like no other place in California. This is a land that people love.

It is not doing so well.

The Coequal Goals, the Delta Stewardship Council, and the Delta Plan

Since the middle 1980s, California has been looking for ways to secure the natural and human values of the Delta while maintaining its place in the state's water plumbing. These efforts have generally started in hope and ended in impasse. In recent years environmentalists turned to the courts, using the blunt tool of the federal Endangered Species Act to force curtailment of water exports at certain times. In reaction, water suppliers south of the Delta have complained of "regulatory drought."

In 2009 the Legislature made its latest, most determined bid to find solutions, passing the Delta Reform Act and associated bills. First and foremost, it declared that State policy toward the Delta must henceforth serve two "coequal goals":

- Providing a more reliable water supply for California, and
- Protecting, restoring, and enhancing the Delta ecosystem.

These goals, the Legislature added, must be met in a manner that:

- Protects and enhances the unique cultural, recreational, natural resource, and agricultural values of the Delta as an evolving place.

By affirming the equal status of ecosystem health and water supply reliability, the Legislature changed the terms of the conversation. It changed them further with the following pronouncement: "The policy of the state of California is to reduce reliance on the Delta in meeting California's future water supply needs." Here was recognition that, for the sake of the water system and the Delta both, a partial weaning of the one from the other is required.

The Delta Stewardship Council is the body entrusted with giving practical meaning to these directives. Publication of this Delta Plan completes its first assignment. The product of eight drafts, almost 100 public meetings, and nearly 10,000 comments, the Delta Plan pulls together in one place the steps that need to be taken to meet the coequal goals—measures that, in one way or another, could affect almost everyone in California. The Plan is to be revised every 5 years, or sooner as circumstances change.

The Delta Plan contains 87 provisions, some broad and some narrowly technical, some novel, some commonsensically familiar. What, in essence, does the Plan propose be done differently? At the risk of oversimplification, we can say that it asks California and Californians to do six large things:

- In order to improve and secure our water supply, while taking pressure off the Delta, we must use water more efficiently in cities and on farms, and develop alternative, usually local, sources.
- We must also get much better at capturing and storing the surplus water that nature provides in the wettest years, building reserves that can be drawn on in dry ones.
- To revitalize the Delta ecosystem, we must provide adequate seaward flows in Delta channels, on a schedule more closely mirroring historical rhythms: what the Plan calls natural, functional flows.
- We must also bring back generous wetlands and riparian zones in the Delta for the benefit of fish and birds.
- To preserve the Delta as a place, we must restrict new urban development to those peripheral areas already definitely earmarked for such growth, while supporting farming and recreation in the Delta's core.
- And we must floodproof the Delta, as far as feasible, mainly by improving levees and by providing more overflow zones where swollen rivers can spread without doing harm.

What about today's headline issue concerning the Delta—the proposed construction of tunnels to improve the way water destined for export southwards reaches the pump intakes near Byron? This initiative is part of what is called the Bay Delta Conservation Plan (BDCP). The BDCP is a different and more narrowly focused undertaking than the Delta Plan, into which, if certain conditions are met, it will be fused (see section, A Better System: Delta Conveyance).

The Delta Plan is *California's* plan for the Delta, prepared in consultation with, and to be carried out by, all agencies in the field: the State Water Resources Control Board, ultimate arbiter of water rights and water quality; the California Department of Water Resources, the state's water planner and also operator of the great State Water Project; the California Department of Fish and Wildlife, responsible for the welfare of the living system of the Delta; the Delta Protection Commission, which oversees land use and development on low-lying Delta islands; and many more agencies, State and local. Add to the list federal players like the Bureau of Reclamation, which runs the Central Valley Project; the U.S. Fish and Wildlife Service; the National Marine Fisheries Service; and the U.S. Army Corps of Engineers. Their cooperation has been promised, and it is vital.

The working parts of the Plan are 73 *Recommendations* and 14 *Policies*. *Recommendations* call attention to tasks being done or to be done by others. *Policies* are legal requirements that anyone undertaking a significant project in the Delta must meet. See the sidebar, From Plan to Reality, for more on the mechanics of realizing the Plan and pages ES-15 to ES-35 for a survey of all 87 provisions.

Where Is the Money?

The Legislature sees "adequate and secure funding" as a need "inherent in the coequal goals." In order to know what this entails, we need to form a clearer picture of the costs of the work now proposed for the Delta or on its behalf and how those costs might be met. This first edition of the Delta Plan proposes research toward that clarity.

FROM PLAN TO REALITY

The Legislature instructed the Delta Stewardship Council to "direct efforts across state agencies." This "direction" has three distinct aspects.

First of all, the Council is to **coordinate**. It will chair a high-powered committee dedicated to implementing the Plan. The heads of key State and local agencies will be at that table, together with federal representatives. This body will meet for the first time in fall 2013. Agency staffs will work with that of the Council daily.

Second, the Council is to **keep track of progress**. Using specific performance metrics contained in the Plan, and guided by the Delta Science Program (see sidebar, Science at the Center), it will monitor what is actually being done toward Plan goals, and what changes of course may be indicated. The results will be widely publicized.

Third, in certain key areas, the Council can be called upon to **block damaging actions**. The Plan provisions that can trigger this authority are called Policies. To avoid premature encroachment on the work of other agencies, the Legislature devised an indirect path leading to Council intervention.

Actions subject to these Policies are called "covered actions," but the Council itself cannot declare an action to be covered. It is the proposing agency that makes this determination. Legal standards apply, however, and if an action is questionably deemed not to be covered, the Council or any other party can take the agency to court.

Once an action is determined to be covered, the proposing agency must make sure it is in line with the Policies of the Delta Plan, filing a Certification of Consistency with contents specified in Delta Plan **Governance Policy 1**. If the agency says the action is consistent but another party or citizen thinks it is not, the opponent can then appeal to the Delta Stewardship Council. A Council member or the Council's Executive Officer may initiate the appeal.

SCIENCE AT THE CENTER

The Delta Reform Act mandates that the Delta Plan be based on the best available scientific knowledge of our day. It must, moreover, be open to change as knowledge changes—and as paper proposals meet the test of reality. The results of every action are to be closely tracked, so that corrections can be made in a timely way—a process, much discussed but not sufficiently practiced, known as adaptive management.

To be more than a buzzword, adaptive management must bring two things to bear: new information, and a readiness to let new information disrupt old plans. Both, in the past, have been in scant supply.

Though Delta knowledge has expanded hugely in recent years, it is often a challenge to pull that data together and draw conclusions from it. Studies are done by different agencies for specific purposes and in narrow contexts; findings can be hard to integrate. The Delta Science Program, a function of the Council, will seek to overcome these gaps, linking the whole community of scientists at work. Guided by a top-flight Delta Independent Science Board, it will prepare, by December 31, 2013, a companion to the Delta Plan called the Delta Science Plan (**Governance Recommendation 1**).

The Delta Science Plan will propose a collaborative structure for doing science in the Delta. It will suggest ways of improving communication, resolving conflicting results, and accommodating uncertainty. It will offer priorities: how to apportion attention between immediate practical questions, on the one hand, and research aimed at increasing long-term understanding, on the other. It will sketch a more integrated approach to monitoring, so that results from different settings can be compared, and consider how computer modeling of the intricate Delta system might be improved.

Once a year, the Council will bring scientists together to assess what has been learned and what changes in ongoing plans and projects the new knowledge may suggest. Another conference? Yes, but with a difference: These findings will feed directly into ongoing refinement of the Delta Plan.

First step is an inventory: How much is now actually being spent, by all the agencies involved, that can be chalked up to furthering the coequal goals? Second comes an assessment of costs: How much will it take to carry out the projects and programs described in the Delta Plan, and what might the sources of support be for each one? The third step must be a comparison of resources and needs, and a reckoning of gaps: What key elements lack probable funding, and what might be done to fill these holes? (**Funding Principles Recommendations 1 through 3**.)

Providing a More Reliable Water Supply for California...

The Delta's contribution to the overall statewide water supply is smaller than many people think. The proportion drawn directly from the Delta, mostly through the pumps near Byron, is only about 8 percent of the total. The bulk of California's water comes from more local sources, and always has.

Nevertheless, the Delta supply is important to many regions. Southern California imports about 25 percent of its water via the Byron pumps. The Tulare Lake Basin, the southern end of the Great Central Valley, gets 27 percent of its water by that route. Even the San Francisco Bay Area takes 16 percent of its supply from Delta pumps. On a more local scale, several water suppliers rely entirely on the Delta, and others have become dependent on this one overtaxed source to a risky degree.

In addition to water pulled directly from the Delta, a great deal is drawn from the Delta's tributary streams before they come down to sea level. San Francisco Bay Area cities reach far inland to tap the Tuolumne and Mokelumne Rivers in the Sierra Nevada, taking 27 percent of their water needs from these sources. Parts of the Central Valley tributary to the Delta get all of their water from that watershed by definition, as do the people and farms of the Delta itself. (See also sidebar, The Problem with Numbers.)

California water planning is full of good intentions. If the laws and policies that are now on the books were consistently carried out, the state's water system—including that part that is tied to the Delta—would work much better.

The Delta Plan addresses water supply on three scales: California-wide, on the Delta watershed level, and in the areas that receive water from the Delta pumps. (See Figure ES-1, The Delta Watershed and Areas Receiving Delta Water.)

California water planning is full of good intentions. If the laws and policies that are now on the books were consistently carried out, the state's water system—including that part that is tied to the Delta—would work much better. The Delta Plan calls on *all* water suppliers to obey the many laws and guidelines that exist, and on the State's regulatory agencies to insist on compliance (**Water Resources Recommendation 1**).

THE PROBLEM WITH NUMBERS

In talking of California water, we put trust in numbers: flows, usages, capacities, trends. But some seemingly solid and much-quoted figures are little more than guesses. By and large, we do not truly know how much water we are using or how much we are saving through conservation efforts. We know less than we should about Delta inflows and outflows. We know little about groundwater except that water tables in too many places are dropping. What information is available is often packaged in inscrutable ways. The Delta Plan asks all the agencies and water suppliers involved to provide or demand better information, and to communicate it better (**Water Resources Policy 2, WR Recommendations 16 through 19**).

Whatever the outcome of some current debates, California's next large increment of water supply will not come from major new engineering but from water conservation, recycling, local stormwater capture, and reasonable use of aquifers (see section, A Better System: Storing Floods to Ride Out Droughts). These measures can yield an amount of water larger than the total that is drawn from the Delta today. State agencies in charge of water matters should systematically promote these practices, and *all* State agencies should model them in their own water usage. (**Water Resources Recommendations 6, 8, and 14**.)

The Delta Watershed and Areas Receiving Delta Water

Figure ES-1

Zooming in a bit from the statewide picture, the Delta Plan calls for all water users linked to the Delta—whether they take water from it directly, or tap the watershed—to reduce their draws. The State Water Resources Control Board should give special scrutiny to water use applications that could boost demand on the watershed. Urban and agricultural water suppliers are already required to write water management plans; these now should include "water supply reliability elements," discussing, among other things, how to deal with the cascading effects if Delta pumping were halted for as long as 3 years. (**Water Resources Recommendations 3, 4, 5, and 7**.)

The Plan speaks most directly to those suppliers that serve water within the Delta or pump water out of the region—including the State Water Project, the Central Valley Project, and by extension the many agricultural and urban water purveyors that are the customers of these giants. Any organization that receives water from the projects must do its share to reduce reliance on the Delta, setting specific reduction targets and actually putting measures in place. The State Water Project is called on to write the corresponding provisions into contracts with its clients when these agreements are renewed or revised (**Water Resources Policies 1 and 2, WR Recommendation 2**).

A Better System: Storing Floods to Ride Out Droughts (and Give the Delta a Break)

The measures so far mentioned will take pressure off the Delta while actually increasing California's developed water supply. The further key to both goals is to harvest and store the water that is available from Central Valley rivers in the wettest years, at the least environmental cost. The need is heightened by the fact of climate change, which stands to make rainy years all the wetter, and droughts all the more severe.

There are few opportunities left in California to build large new dams (or to raise the height of old dams), and the options that exist are dauntingly expensive. The California Department of Water Resources and the Bureau of Reclamation have been studying the possibilities. The Delta Plan urges the agencies to wrap up these studies, so that the State can decide the fate of these proposals once and for all (**Water Resources Recommendations 13 and 14**).

Much more water storage space exists right under our feet: in groundwater basins, or aquifers.

California began its history with a vast supply of water stored naturally in underground gravel fields and free for the taking via wells. In parts of the state, including most of the southern Central Valley, this endowment has been squandered, and groundwater levels have dropped, sometimes by hundreds of feet. One of the rationales for sending water south from the Delta has been to recharge aquifers, but not enough recharging has occurred. And the State's last comprehensive assessment of its groundwater situation was published in 1980—a third of a century ago.

The Delta Plan calls for a rededication to the conservative idea of using aquifers like bank accounts: to be filled up in wet times, in order that they may be drawn from in dry. It calls on the State to do the indispensable groundwater update, on local suppliers to write plans for sustainable groundwater management, and on the State Water Resources Control Board to stand ready to intervene in seriously overdrafted areas, if good local plans are not forthcoming, leading perhaps to the court procedure called groundwater adjudication. (**Water Resources Recommendations 9, 10, 11, and 14**.)

The Delta Plan calls for a rededication to the conservative idea of using aquifers like bank accounts: to be filled up in wet times, in order that they may be drawn from in dry.

There is another tool for making the supply stretch further: the sale or trade of water between suppliers, especially in times of shortage. Existing rules governing such transfers are found cumbersome by some and insufficiently protective of water rights and the environment by others. The State Water Resources Control Board should reformulate the guidelines by mid-2016 (**Water Resources Recommendations 14 and 15**).

A Better System: Delta Conveyance

As noted, many of the state's water suppliers take their water from rivers at points upstream of the Delta. The two biggest, however—the State Water Project and the Central Valley Project—are different. Though most of the water they transport has its origin to the north, in the Sacramento River, their withdrawal points are deep in the Delta and well to the south, on the channel called Old River. Unlike most other water withdrawals, these affect the region not only by removing water but also by distorting flows.

The pumps at Byron have so much power that they essentially give the Delta a second mouth. In many channels, water runs backward at times, toward the pump intakes, not toward the sea. This situation is bad for salmon, Delta smelt, and other sensitive and legally protected species. Under the Bay Delta Conservation Plan, the Department of Water Resources and the federal Bureau of Reclamation are planning a kind of arterial bypass, segregating the water meant for the pumps at a new northern intake on the Sacramento River. The water corralled at this point would be sent to the pumps via a pair of tunnels. This arrangement is intended to alleviate the backward flows that harm fish; in conjunction with major habitat improvements and other measures, it is supposed to bring endangered species far enough back from the brink to satisfy protective laws. Many Delta residents and environmentalists, though, fear that the new system will simply allow more water to be shipped south, doing, on balance, more harm than good.

The Delta Stewardship Council is not the author of the BDCP. Its role for now is to advise and to urge timely completion (**Water Resources Recommendation 12**). Later on, though, the Council may have a decisive say. Once the proposal is complete, the Department of Fish and Wildlife must declare that it meets the standards of the Delta Reform Act, and this declaration can in turn be appealed to the Council. If the Council does not concur, certain aspects of the BDCP will lose access to State funding. If all hurdles have been cleared, on the other hand, the BDCP will take its place as a component of the Delta Plan.

...and Protecting, Restoring, and Enhancing the Delta Ecosystem...

The effort to improve the fortunes of the Delta ecosystem has two components that are vital: guaranteeing adequate flows from the rivers feeding into and through Delta channels, and creating new wetlands and other habitats in partial replacement for what has been lost. Three other components are merely very important: combating harmful exotic species, improving the management of salmon hatcheries, and protecting and improving water quality.

Toward "Natural Functional Flows"

Humans have not only reduced the total quantity of runoff through the Delta toward the ocean but also have changed its timing, decreasing the historical torrents of spring and increasing the formerly feeble flows of autumn. In a natural system that evolved with wide variation, this shift toward a steady state is itself a source of harm.

Humans have not only reduced the total quantity of runoff through the Delta toward the ocean but also have changed its timing, decreasing the historical torrents of spring and increasing the formerly feeble flows of autumn.

The minimum seaward flows to be maintained in Delta channels are set by the State Water Resources Control Board, according to season and year type (wet, above normal, below normal, dry, or critical). These required flows help fish; they also prevent saltwater intrusion. As a not-incidental side effect, the rules limit the amount of water that can be exported through the pumps.

The Water Board is now preparing to revise this flow regime, last updated in 2006. As a later step, the Water Board is to issue comparable flow standards for the major tributary rivers of the Delta. The Delta Plan recommends deadlines for these processes (mid-2014 and mid-2018). The adopted regulations will become elements of the Plan. The Delta Stewardship Council can be called upon to review any project that could affect Delta flows in the light of adopted flow criteria (**Ecosystem Restoration Policy 1, ER Recommendation 1**).

Habitat Restoration

In its primeval state, the Delta was no uniform sea of reeds but a vast mesh of habitats including tule marsh threaded with rivers and sloughs, perched lakes filled by floods and very high tides, natural levees with big trees on them, and seasonal overflow basins behind the levees. Most of this mosaic has disappeared, converted to fifty large and many small leveed islands. Evidence of what was remains in agricultural soils of uncommon quality (and fragility).

The old scene will never return, but careful habitat restoration projects can help to reverse the region's ecological decline. Biologists have spent years locating the likeliest areas for such revival. The Delta Plan incorporates the latest thinking, essentially the Conservation Strategy drafted in 2011 by the Department of Fish and Wildlife (formerly the Department of Fish and Game).

Since the heart of the Delta is now well below sea level, due to subsidence, the suitable restoration sites are mostly found near Delta margins, where the soil surface is still high enough to permit marsh plants and riparian vegetation to take root. The Plan outlines six such zones: the Yolo Bypass, the floodplain west of Sacramento into which the Sacramento River spills in wet years; the Cache Slough Complex, where the Bypass rejoins the body of the Delta; a nexus in the eastern Delta, where the Mokelumne River and the Cosumnes River add their strands to the Delta's web; a zone in the southern Delta along the San Joaquin River; a collection of small tracts at the western apex of the Delta, where it narrows to meet Suisun Bay; and finally the Suisun Marsh, fringing that bay to the north. This fresh-to-brackish water marsh, the largest wetland in California, is mostly managed by hunting clubs for seasonal waterfowl ponds, but sizeable areas should be restored to full tidal action. The existing plan for Suisun Marsh, written by the San Francisco Bay Conservation and Development Commission, is 36 years old and does not take into account, for example, probable sea level rise.

The Delta Plan calls for the habitat restorations in the Conservation Strategy to be carried out by the Department of Fish and Wildlife and by the Delta Conservancy, a body established for such purposes in 2009; and it calls for a plan update for Suisun Marsh. The Delta Stewardship Council can be appealed to, if necessary, to block development or any other intrusion that might interfere with a restoration site. (**Ecosystem Restoration Policies 2 and 3, ER Recommendations 2, 3, and 5**.)

Much of the remaining good habitat in the Delta is found in strips along the water side of levees, and the Delta Plan looks to protect and widen these green margins. When levees are rebuilt or altered, the possibility of shifting them farther away from the water should always be explored. The growth of trees along the waterline should be encouraged. However, authority over many levees lies with the U.S. Army Corps of Engineers, and the Corps requires removal of trees and shrubs, on the theory that root systems have a weakening effect. (The matter is debated.) Given the value of tall vegetation for habitat, the Delta Plan asks the Corps to exempt Delta levees from this rule, where appropriate. (**Ecosystem Restoration Policy 4 and ER Recommendation 4**.)

Exotic Species

One of the less-visible forces to buffet the Delta ecosystem is the proliferation of nonnative aquatic species—fish, crustaceans, plants, and even the microscopic floating animals of zooplankton. Some were introduced deliberately; others arrived by random routes including the discharge of bilgewater from oceangoing ships and the dumping of goldfish bowls.

New arrivals keep appearing. Some of these intruders affect the system little, but other species, notably certain aquatic plants and filter-feeding clams, transform the web of life profoundly. The Delta Plan prohibits actions that could bring in new exotics or improve conditions for exotics that are here, and endorses the measures the Department of Fish and Wildlife is already planning to take against them. (**Ecosystem Restoration Policy 5, ER Recommendation 7**.)

Among the exotics are game species introduced in the nineteenth century and well-loved by fishermen: striped, largemouth, and smallmouth bass. It has become apparent that these voracious game fish are helping to deplete salmon, Delta smelt, and other species in trouble. The Delta Plan asks the Department of Fish and Wildlife to change angling rules to permit heavier fishing and somewhat suppress the bass population (**Ecosystem Restoration Recommendation 6**).

Management of Hatchery Fish

When dams on many rivers cut off spawning grounds for salmon and steelhead trout, hatcheries were built to compensate. Now there is worry that hatchery-raised salmon, less genetically diverse than their wild cousins, may mix with and reduce the fitness of the wild strains. Various solutions are proposed, including capturing wild fish to add their eggs to hatchery stock. The Delta Plan asks the Department of Fish and Wildlife and the U.S. Fish and Wildlife Service to put these ideas and recommendations into effect (**Ecosystem Restoration Recommendations 8 and 9**).

Water Quality

Pollution from the watershed is bad for the Delta ecosystem and for water users. The Delta Plan urges the responsible agencies—the State Water Resources Control Board, the Central Valley Regional Water Quality Control Board, and the San Francisco Bay Regional Water Quality Control Board—to protect "beneficial uses" of water in the Delta and Suisun Bay. Various ongoing projects of planning, rulemaking, and construction should be brought to conclusion. All agencies should look at water quality when weighing actions covered under the Delta Plan. Special attention should be paid to pollution that might degrade habitat restoration sites. (**Water Quality Recommendations 1 through 12**.)

...In a Way that Protects and Enhances the Values of the Delta as an Evolving Place

Because of its role in greater systems—the San Francisco Estuary, the state water plumbing—the Delta is a subject of statewide debate. The conversation can seem to take place over the heads of the people who actually live in the region; and it can seem to overlook the lasting values of the place that is: its thriving agriculture, the beauty of its countryside, its cultural heritage, and its recreational bounty. The Delta Plan strives to redress this balance without promising what is probably impossible: the retention of the landscape exactly as it is today.

Honorific labels do not protect valuable assets, but they can help us recognize them. The Delta Plan asks that the Delta be declared a National Heritage Area by Congress and that Highway 160, its north-south artery, be designated a National Scenic Byway by the U.S. Department of Transportation (**Delta-as-Place Recommendations 1 and 2**).

Many Delta people fear that their concerns will be brushed aside as new water facilities and habitat restorations get under way. While deference cannot be guaranteed, the Delta Plan calls on the agencies to respect local plans in siting such projects, to minimize conflict when possible, and to buy land from willing sellers when they can (**Delta-as-Place Policy 2, DP Recommendation 4**).

The distinctive Delta landscape has been much altered by urban encroachment, often entailing higher flood risk. The Delta Protection Commission, created in 1992 and strengthened by the Delta Reform Act of 2009, oversees development in the core area called the Primary Zone: Local decisions affecting this zone can be appealed to the Commission and overturned by it. However, this authority does not extend to the peripheral Secondary Zone, where the development pressure is strongest. The Delta Plan tightens control further, steering new development to the 26,000 acres in the Peripheral Zone that are already earmarked for urbanization in local plans. Small housing developments that may occur outside these limits must meet high flood control standards (**Delta-as-Place Policy 1, Risk Reduction Policy 2**). (See Figure ES-2, Delta Communities.)

A little more bustle might actually benefit 11 historic small towns or settlements within the Delta, known as the legacy communities. Most are spaced along the Sacramento River: Freeport, Clarksburg, Hood, Courtland, Locke, Walnut Grove, Ryde, Isleton, and Rio Vista. Knightsen and Bethel Island are near the lower channel of the San Joaquin River. Planners at all levels should respect the character, and promote the vitality, of these places (**Delta-as-Place Recommendation 3**).

The Delta Protection Commission has written an Economic Sustainability Plan containing numerous ideas for the support of the region's farm economy, parks and recreation, and roads and infrastructure. The Delta Plan adapts many of these as **Delta-as-Place Recommendations 5 through 19**.

Flood Risk Reduction

In its primeval state, most of the Delta was wetland and slightly above sea level. Since levees created the modern islands and cultivation began, soils have subsided deeply. Many Delta tracts are strikingly below the level of the water in adjacent channels; rising sea level will make the differential worse. While the occasional levee break is part of Delta lore, multiple failures could bring disaster to the Delta landscape, economy, and ecosystem.

The Delta Plan urges all agencies in the Delta to plan for emergencies and to join forces in a regional response consortium, as proposed by the Delta Multi-Hazard Coordination Task Force. Every responsible party, public and private, should allocate money for flood prevention and reaction. Utilities should plan to minimize interruptions of service. The Department of Water Resources should expand its stockpiles of stone and earth for the use of all when breaches require rapid plugging. Higher levels of private flood insurance should be required, and the State should gain immunity from lawsuits related to flooding beyond its power to prevent. (**Risk Reduction Recommendations 1, 9, and 10**.)

It is estimated that only about half the Delta's acreage is adequately protected. There is not enough money for all the desirable improvements, nor is there a mechanism for sharing costs among all who benefit.

Delta Communities

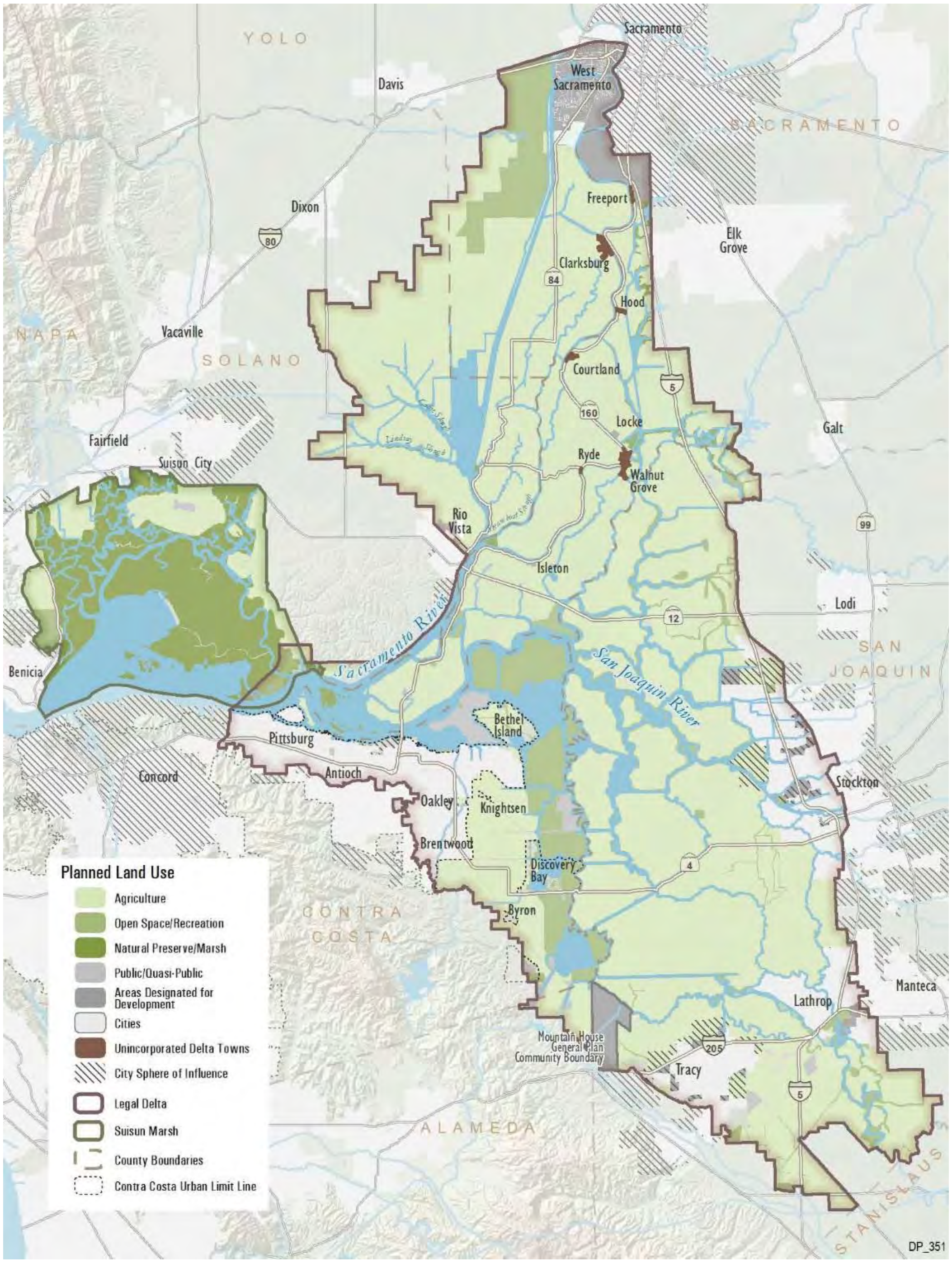


Figure ES-2 *Sources: City of Benicia 2003, Contra Costa County 2008, Contra Costa County 2010, City of Fairfield 2008, City of Lathrop 2012, City of Manteca 2012, Mountain House Community Services District 2008, City of Rio Vista 2001, SACOG 2009, City of Sacramento 2008, Sacramento County 2011, Sacramento County 2012, Sacramento County 2013, San Joaquin County 2008a, San Joaquin County 2008b, Solano County 2008a, Solano County 2008b, City of Stockton 2011a, City of Stockton 2011b, City of Suisun City 2011, City of Tracy 2011a, City of Tracy 2011b, City of West Sacramento 2010, Yolo County 2010a, Yolo County 2010b.*

There are more than 1,000 miles of Delta levees. The State is directly responsible for about one-third of the system; nearly 70 local Reclamation Districts are in charge of the rest. It is estimated that only about half the Delta's acreage is adequately protected. There is not enough money for all the desirable improvements, nor is there a mechanism for sharing costs among all who benefit. The Delta Plan calls on the Legislature to establish a locally based Delta Flood Risk Management Assessment District to raise money for combined defenses. Public and private utilities, too, should invest in defense of their facilities and lines. (**Risk Reduction Recommendations 2 and 3**.)

The State contributes massively to levee costs throughout the Delta, but on a not very systematic basis. The Legislature directed the Delta Stewardship Council to set priorities for these investments. **Risk Reduction Policy 1** offers broad principles. Urban areas come first; special attention must be paid to levees guarding roads and energy facilities. The channels through which water flows toward export pumps require protection, as does the pipeline that brings Sierra water across the Delta for the East Bay Municipal Utility District. Levees on the western islands, whose failure could bring salinity deep into the Delta, are also of high concern.

A more detailed study is to follow. Building on work being done by the Department of Water Resources, the Council will assess, island by island, the state of levees, the degree of subsidence, the extent and value of assets to be protected, and the cost of long-term defense. The result, due at the end of 2014, will be a tiered priority list for the expenditure of State levee funds (**Risk Reduction Recommendation 4**).

To take pressure off the levee system, floodwaters need room to move and to spread without causing harm (and often to the benefit of plants, birds, and fish). Two such safety valves already exist at the Yolo Bypass and the Cosumnes-Mokelumne floodplain; a third such zone is proposed for the lower San Joaquin River at Paradise Cut. The Delta Plan urges expansion of the flood relief system, and requires that present or potential overflow areas be kept free of encroachments. Levee setbacks are also encouraged. (**Risk Reduction Policies 3 and 4, RR Recommendations 5 through 8**.)

Given time, land subsidence can actually be reversed. Experimental plots show that soils can be deepened by growing tules in shallowly flooded fields, at a rate of a little over an inch a year. The tule plots also fix a lot of atmospheric carbon and thus do their bit toward slowing climate change. The Delta Plan encourages expansion of this work (**Delta-as-Place Recommendation 7**).

Finding the Way Through

When the first Spanish explorers took their boats into the Sacramento-San Joaquin River Delta, they were feeling their way. They could see the channel they were in, as far as the next bend or junction of sloughs. They had a general idea of where they were going. Between the near and the far, though, were mysteries. Which waterways connected to others, which petered out in the marshes? Where was the real way through?

Tangible marks of progress may at first be as subtle as shifting shoreline features seen from a Delta boat.

This first edition of the Delta Plan is a little like such an exploration. A short reach of channel is visible; another stretch can be assessed from local information. After that, the route is a matter of educated guesswork.

The Delta Plan can be fairly specific about steps to be taken in the next 5 years. The Delta Science Plan is already under way. The in-depth study of levees will begin by fall 2013. The Interagency Implementation Committee will meet by the end of the year. Just around the next bend, the State Water Resources Control Board will adopt its momentous new flow rules; a final decision on Delta conveyance (the Bay Delta Conservation Plan) looms beyond that.

It will not have escaped the reader how many of these measures seem rather abstract, involving studies, rule-making, the gathering of information, the refining of procedures, the testing of powers—not so much doing as planning, and even planning how to plan. This is simply the phase we are in. Tangible marks of progress may at first be as subtle as shifting shoreline features seen from a Delta boat. Here, though, are some markers to look for. We will be doing well if, in a few years' time:

- Many urban and rural water suppliers that draw on the Delta have taken real steps to reduce that reliance, with measured, reported results.
- Flows in Delta channels, controlled under new State Water Resources Control Board rules, are looking a good deal more like the historical ones.
- Several new habitat restoration projects in the Delta have moved from the planning to the construction stage.
- Subsidence reversal planting has expanded from the small pilot projects seen today.
- Measurably less acreage of Delta waters is dominated by nonnative water plants.
- Stocks of endangered fish are showing a rebound.
- Key levees have been strengthened, especially in the environs of Stockton and Sacramento.
- No further rural farmland has been lost to urbanization.

The next edition of the Delta Plan, due in 2018 or sooner, will be a little longer on specifics and a little shorter on question marks. A few more miles of the channel ahead will have come into view. New uncertainties, no doubt, will have replaced old. The captains will continue to disagree. But, just as it was in the old days, the route through the Delta will be the one way forward.

Beyond all local debates and confusions, the destination is clear. We want a Delta landscape that remains essentially itself while adapting gradually and gracefully to a future marked by climate change and sea level rise. We want a Delta ecosystem that works markedly better than today's, reflected partly in a resurgence of native fish. And we want an end to the endless wrangling about Delta flows and plumbing—a truce that can only be achieved if the entire California water system undergoes a measure of reform.

In solving the "Delta problem," we will not only be doing right by a treasured land- and waterscape. We will be putting the entire state of California on a sounder development path.

Driven by cost, environmental concern, and sheer practicality, the water world is already shifting away from reliance on distant dams and aqueducts and toward trust in conservation, local sources, and better use of groundwater storage. This change is reflected in the fact, startling to many, that California's total water consumption has not climbed in recent years; in fact, despite our increasing population, use has slightly dropped. The Delta Plan gives a push to trends already under way.

In solving the "Delta problem," we will not only be doing right by a treasured land- and waterscape. We will be putting the entire state of California on a sounder development path.

References

California Department of Fish and Game. 2011. *Conservation Strategy for Restoration of the Sacramento-San Joaquin Delta Ecological Management Zone and the Sacramento and San Joaquin Valley Regions*. Draft. July.

City of Benicia. 2003. General Plan land use designations within Suisun Marsh. Digitized into GIS format by AECOM from City of Benicia Land Use map in 2012.

City of Fairfield. 2008. General Plan land use designations within Suisun Marsh. Received from the City of Fairfield in 2012.

City of Lathrop. 2012. General Plan Land Use map for the City of Lathrop. October. Site accessed March 14, 2013. http://www.ci.lathrop.ca.us/cdd/documents/.

City of Manteca. 2012. General Plan land use designations in GIS format. Received by Eryn Pimentel, AECOM, from Jeffrey Davis, City of Manteca, on September 4.

City of Rio Vista. 2001. General Plan land use designations in electronic non-GIS format. Site accessed 2009. http://www.riovistacity.com/images/Documents/chapter_04.pdf.

City of Sacramento. 2008. General Plan land use designations in electronic GIS format. Site accessed 2009. http://www.cityofsacramento.org/gis/data.html.

City of Stockton. 2011a. GIS layers for city spheres of influence and General Plan land use designations. Site accessed April 14, 2011. http://www.stocktongov.com/services/gis/mapdatDat.html.

City of Stockton. 2011b. General Plan land use designations in GIS format and General Plan land use designations within Suisun Marsh (digitized into GIS format by AECOM from Land Use map in 2012). Site accessed April 14, 2011. http://www.stocktongov.com/services/gis/mapdatDat.html.

City of Suisun City. 2011. General Plan land use designations within Suisun Marsh. Digitized into GIS format by AECOM from Land Use map in 2012.

City of Tracy. 2011a. General Plan land use designations provided in GIS format. Delivered via file transfer protocol from Victoria Lombardo, Senior Planner, City of Tracy, to Jessica Law, Urban and Environmental Planner, AECOM, on March 10, 2011.

City of Tracy. 2011b. City of Tracy. 2011. City of Tracy Sphere of Influence provided in GIS format. Delivered via file transfer protocol from Victoria Lombardo, Senior Planner, City of Tracy, to Jessica Law, Urban and Environmental Planner, AECOM, on March 10, 2011.

City of West Sacramento. 2010. General Plan land use designations in GIS format. Site accessed December 28, 2010. http://www.cityofwestsacramento.org/services/gis/downloads.cfm.

Contra Costa County. 2008. GIS layer for Urban Limit Line for Contra Costa County. October. Site accessed June 27, 2011. http://ccmap.us/Details/asp?Product=134490.

Contra Costa County. 2010. GIS layer for City Spheres of Influence in Contra Costa County. January. Site accessed January 28, 2011. https://www.ccmap.us/catalog.asp?UserChoice=2&Layercntrl=0000000000000000000000.

Mountain House Community Services District. 2008. Mountain House Zoning map. September 18, 2008. Site accessed July 27, 2011. http://www.ci.mountainhouse.ca.us/master-plan.asp.

SACOG (Sacramento Area Council of Governments). 2009. GIS layer for Spheres of Influence in SACOG region. December. Site accessed January 28, 2011. http://sacog.org/mapping/clearinghouse/Mapping Center.

Sacramento County. 2011. General Plan land use designations in GIS format. Site accessed 2012. http://www.sacgis.org/GISDataPub/Data/.

Sacramento County. 2012. Letter from Sacramento County to the Delta Stewardship Council, Re: Revised Maps of the Unincorporated Delta Communities. November 20.

Sacramento County. 2013. Sacramento County Online Map, Sacramento County, California. Site accessed March 10, 2013. http://generalmap.gis.saccounty.net/JSViewer/county_portal.aspx

San Joaquin County. 2008a. City of Lathrop SOI map. March 4. Site accessed February 3, 2011. http://www.sjgov.org/lafco/SOI%20Maps/Lathrop_Sphere_new%202008.pdf.

San Joaquin County. 2008b. City of Manteca SOI map. October 29. Site accessed February 3, 2011. http://www.co.san-joaquin.ca.us/lafco/Manteca%20MSR/Manteca_Sphere.pdf.

Solano County. 2008a. GIS layer for City Spheres of Influence in Solano County. May. Site accessed August 10, 2011. http://regis.solanocounty.com/data.html.

Solano County. 2008b. General Plan land use designations provided in GIS format. Obtained 2009.

Yolo County. 2010a. General Plan land use designations in GIS format. Site accessed 2010. http://www.yolocounty.org/Index.aspx?page=823.

Yolo County. 2010b. Yolo County General Plan 2030 layer provided in GIS format. Delivered via file transfer protocol from Marcus Neuvert, GIS Specialist, Yolo County DITT, to Dillon Cowan, Staff Engineer, CH2M HILL, Inc., on July 1.

Photo Credits

Chapter divider *(clockwise from top left)***:** California Department of Water Resources, Chris Austin, L.A. Yarbrough, California Department of Water Resources

Delta Plan Policies and Recommendations

The Delta Plan contains a set of regulatory policies that will be enforced by the Delta Stewardship Council's appellate authority and oversight. The Delta Plan also contains priority recommendations, which are nonregulatory but call out actions essential to achieving the coequal goals.

POLICY OR RECOMMENDATION NUMBER	SHORT TITLE	POLICY/RECOMMENDATION LANGUAGE
Chapter 2		
G P1 (23 CCR section 5002)	Detailed Findings to Establish Consistency with the Delta Plan	*(a) This policy specifies what must be addressed in a certification of consistency filed by a State or local public agency with regard to a covered action. This policy only applies after a "proposed action" has been determined by a State or local public agency to be a covered action because it is covered by one or more of the regulatory policies contained in Article 3. Inconsistency with this policy may be the basis for an appeal.* *(b) Certifications of consistency must include detailed findings that address each of the following requirements:* *(1) Covered actions, in order to be consistent with the Delta Plan, must be consistent with this regulatory policy and with each of the regulatory policies contained in Article 3 implicated by the covered action. The Delta Stewardship Council acknowledges that in some cases, based upon the nature of the covered action, full consistency with all relevant regulatory policies may not be feasible. In those cases, the agency that files the certification of consistency may nevertheless determine that the covered action is consistent with the Delta Plan because, on whole, that action is consistent with the coequal goals. That determination must include a clear identification of areas where consistency with relevant regulatory policies is not feasible, an explanation of the reasons why it is not feasible, and an explanation of how the covered action nevertheless, on whole, is consistent with the coequal goals. That determination is subject to review by the Delta Stewardship Council on appeal;* *(2) Covered actions not exempt from CEQA must include applicable feasible mitigation measures identified in the Delta Plan's Program EIR (unless the measure(s) are within the exclusive jurisdiction of an agency other than the agency that files the certification of consistency), or substitute mitigation measures that the agency that files the certification of consistency finds are equally or more effective;* *(3) As relevant to the purpose and nature of the project, all covered actions must document use of best available science;* *(4) Ecosystem restoration and water management covered actions must include adequate provisions, appropriate to the scope of the covered action, to assure continued implementation of adaptive management. This requirement shall be satisfied through both of the following:* *(A) An adaptive management plan that describes the approach to be taken consistent with the adaptive management framework in Appendix 1B, and* *(B) Documentation of access to adequate resources and delineated authority by the entity responsible for the implementation of the proposed adaptive management process.*

POLICY OR RECOMMENDATION NUMBER	SHORT TITLE	POLICY/RECOMMENDATION LANGUAGE
		(c) A conservation measure proposed to be implemented pursuant to a natural community conservation plan or a habitat conservation plan that was: *(1) Developed by a local government in the Delta; and* *(2) Approved and permitted by the California Department of Fish and Wildlife prior to May 16, 2013* *is deemed to be consistent with sections 5005 through 5009 of this Chapter if the certification of consistency filed with regard to the conservation measure includes a statement confirming the nature of the conservation measure from the California Department of Fish and Wildlife.*
G R1	Development of a Delta Science Plan	*The Delta Stewardship Council's Delta Science Program should develop a Delta Science Plan by December 31, 2013. The Delta Science Program should work with the Interagency Ecological Program, Bay Delta Conservation Plan, California Department of Fish and Wildlife, and other agencies to develop the Delta Science Plan. To ensure that best science is used to develop the Delta Science Plan, the Delta Independent Science Board should review the draft Delta Science Plan.* *The Delta Science Plan should address the following:* ▪ *A collaborative institutional and organizational structure for conducting science in the Delta* ▪ *Data management, synthesis, scientific exchange, and communication strategies to support adaptive management and improve the accessibility of information* ▪ *Strategies for addressing uncertainty and conflicting scientific information* ▪ *The prioritization of research and balancing of the short-term immediate science needs with science that enhances comprehensive understanding of the Delta system over the long term* ▪ *Identification of existing and future needs for refining and developing numerical and simulation models along with enhancing existing Delta conceptual models (e.g., the Interagency Ecological Program (IEP) Pelagic Organism Decline (POD) and the Delta Regional Ecosystem Restoration Implementation Plan (DRERIP) models)* ▪ *An integrated approach for monitoring that incorporates existing and future monitoring efforts* ▪ *An assessment of financial needs and funding sources to support science*
Chapter 3		
WR P1 (23 CCR section 5003)	Reduce Reliance on the Delta through Improved Regional Water Self-Reliance	*(a) Water shall not be exported from, transferred through, or used in the Delta if all of the following apply:* *(1) One or more water suppliers that would receive water as a result of the export, transfer, or use have failed to adequately contribute to reduced reliance on the Delta and improved regional self-reliance consistent with all of the requirements listed in paragraph (1) of subsection (c);* *(2) That failure has significantly caused the need for the export, transfer, or use; and* *(3) The export, transfer, or use would have a significant adverse environmental impact in the Delta.*

POLICY OR RECOMMENDATION NUMBER	SHORT TITLE	POLICY/RECOMMENDATION LANGUAGE
		(b) For purposes of Water Code section 85057.5(a)(3) and section 5001(j)(1)(E) of this Chapter, this policy covers a proposed action to export water from, transfer water through, or use water in the Delta, but does not cover any such action unless one or more water suppliers would receive water as a result of the proposed action. *(c) (1) Water suppliers that have done all of the following are contributing to reduced reliance on the Delta and improved regional self-reliance and are therefore consistent with this policy:* *(A) Completed a current Urban or Agricultural Water Management Plan (Plan) which has been reviewed by the California Department of Water Resources for compliance with the applicable requirements of Water Code Division 6, Parts 2.55, 2.6, and 2.8;* *(B) Identified, evaluated, and commenced implementation, consistent with the implementation schedule set forth in the Plan, of all programs and projects included in the Plan that are locally cost effective and technically feasible which reduce reliance on the Delta; and* *(C) Included in the Plan, commencing in 2015, the expected outcome for measurable reduction in Delta reliance and improvement in regional self-reliance. The expected outcome for measurable reduction in Delta reliance and improvement in regional self-reliance shall be reported in the Plan as the reduction in the amount of water used, or in the percentage of water used, from the Delta watershed. For the purposes of reporting, water efficiency is considered a new source of water supply, consistent with Water Code section 1011(a).* *(2) Programs and projects that reduce reliance could include, but are not limited to, improvements in water use efficiency, water recycling, stormwater capture and use, advanced water technologies, conjunctive use projects, local and regional water supply and storage projects, and improved regional coordination of local and regional water supply efforts.*
WR R1	Implement Water Efficiency and Water Management Planning Laws	*All water suppliers should fully implement applicable water efficiency and water management laws, including urban water management plans (Water Code section 10610 et seq.); the 20 percent reduction in statewide urban per capita water usage by 2020 (Water Code section 10608 et seq.); agricultural water management plans (Water Code section 10608 et seq. and 10800 et seq.); and other applicable water laws, regulations, or rules.*
WR R2	Require SWP Contractors to Implement Water Efficiency and Water Management Laws	*The California Department of Water Resources should include a provision in all State Water Project contracts, contract amendments, contract renewals, and water transfer agreements that requires the implementation of all State water efficiency and water management laws, goals, and regulations, including compliance with Water Code section 85021.*
WR R3	Compliance with Reasonable and Beneficial Use	*The State Water Resources Control Board should evaluate all applications and petitions for a new water right or a new or changed point of diversion, place of use, or purpose of use that would result in new or increased long-term average use of water from the Delta watershed for consistency with the constitutional principle of reasonable and beneficial use. The State Water Resources Control Board should conduct its evaluation consistent with Water Code sections 85021, 85023, 85031, and other provisions of California law. An applicant or*

POLICY OR RECOMMENDATION NUMBER	SHORT TITLE	POLICY/RECOMMENDATION LANGUAGE
		petitioner should submit to the State Water Resources Control Board sufficient information to support findings of consistency, including, as applicable, its urban water management plan, agricultural water management plan, and environmental documents prepared pursuant to the California Environmental Quality Act.
WR R4	Expanded Water Supply Reliability Element	*Water suppliers that receive water from the Delta watershed should include an expanded water supply reliability element, starting in 2015, as part of the update of an urban water management plan, agricultural water management plan, integrated water management plan, or other plan that provides equivalent information about the supplier's planned investments in water conservation and water supply development. The expanded water supply reliability element should detail how water suppliers are reducing reliance on the Delta and improving regional self-reliance consistent with Water Code section 85201 through investments in local and regional programs and projects, and should document the expected outcome for a measurable reduction in reliance on the Delta and improvement in regional self-reliance. At a minimum, these plans should include a plan for possible interruption of water supplies for up to 36 months due to catastrophic events impacting the Delta, evaluation of the regional water balance, a climate change vulnerability assessment, and an evaluation of the extent to which the supplier's rate structure promotes and sustains efficient water use.*
WR R5	Develop Water Supply Reliability Element Guidelines	*The California Department of Water Resources, in consultation with the Delta Stewardship Council, the State Water Resources Control Board, and others, should develop and approve, by December 31, 2014, guidelines for the preparation of a water supply reliability element so that water suppliers can begin implementation of WR R4 by 2015.*
WR R6	Update Water Efficiency Goals	*The California Department of Water Resources and the State Water Resources Control Board should establish an advisory group with other State agencies and stakeholders to identify and implement measures to reduce impediments to achievement of statewide water conservation, recycled water, and stormwater goals by 2014. This group should evaluate and recommend updated goals for additional water efficiency and water resource development by 2018. Issues such as water distribution system leakage should be addressed. Evaluation should include an assessment of how regions are achieving their proportional share of these goals.*
WR R7	Revise State Grant and Loan Priorities	*The California Department of Water Resources, the State Water Resources Control Board, the California Department of Public Health, and other agencies, in consultation with the Delta Stewardship Council, should revise State grant and loan ranking criteria by December 31, 2013, to be consistent with Water Code section 85021 and to provide a priority for water suppliers that includes an expanded water supply reliability element in their adopted urban water management plans, agricultural water management plans, and/or integrated regional water management plans.*
WR R8	Demonstrate State Leadership	*All State agencies should take a leadership role in designing new and retrofitted State-owned and -leased facilities, including buildings and California Department of Transportation facilities, to increase water efficiency, use recycled water, and incorporate stormwater runoff capture and low-impact development strategies.*

POLICY OR RECOMMENDATION NUMBER	SHORT TITLE	POLICY/RECOMMENDATION LANGUAGE
WR R9	Update Bulletin 118, California's Groundwater Plan	*The California Department of Water Resources, in consultation with the Bureau of Reclamation, U.S. Geological Survey, the State Water Resources Control Board, and other agencies and stakeholders should update Bulletin 118 information using field data, California Statewide Groundwater Elevation Monitoring (CASGEM), groundwater agency reports, satellite imagery, and other best available science by December 31, 2014, so that this information can be included in the next California Water Plan Update and be available for inclusion in 2015 urban water management plans and agricultural water management plans. The Bulletin 118 update should include a systematic evaluation of major groundwater basins to determine sustainable yield and overdraft status; a projection of California's groundwater resources in 20 years if current groundwater management trends remain unchanged; anticipated impacts of climate change on surface water and groundwater resources; and recommendations for State, federal, and local actions to improve groundwater management. In addition, the Bulletin 118 update should identify groundwater basins that are in a critical condition of overdraft.*
WR R10	Implement Groundwater Management Plans in Areas that Receive Water from the Delta Watershed	*Water suppliers that receive water from the Delta watershed and that obtain a significant percentage of their long-term average water supplies from groundwater sources should develop and implement sustainable groundwater management plans that are consistent with both the required and recommended components of local groundwater management plans identified by the California Department of Water Resources Bulletin 118 (Update 2003) by December 31, 2014.*
WR R11	Recover and Manage Critically Overdrafted Groundwater Basins	*Local and regional agencies in groundwater basins that have been identified by the California Department of Water Resources as being in a critical condition of overdraft should develop and implement a sustainable groundwater management plan, consistent with both the required and recommended components of local groundwater management plans identified by the California Department of Water Resources Bulletin 118 (Update 2003), by December 31, 2014. If local or regional agencies fail to develop and implement these plans, the State Water Resources Control Board should take action to determine if the continued overuse of a groundwater basin constitutes a violation of the State's Constitution Article X, Section 2, prohibition on unreasonable use of water and whether a groundwater adjudication is necessary to prevent the destruction of or irreparable injury to the quality of the groundwater, consistent with Water Code sections 2100 and 2101.*
WR R12	Complete Bay Delta Conservation Plan	*The relevant federal, State, and local agencies should complete the Bay Delta Conservation Plan, consistent with the provisions of the Delta Reform Act, and receive required incidental take permits by December 31, 2014.*
WR R13	Complete Surface Water Storage Studies	*The California Department of Water Resources should complete surface water storage investigations of proposed off-stream surface storage projects by December 31, 2012, including an evaluation of potential additional benefits of integrating operations of new storage with proposed Delta conveyance improvements, and recommend the critical projects that need to be implemented to expand the state's surface storage.*
WR R14	Identify Near-term Opportunities for Storage, Use, and Water Transfer Projects	*The California Department of Water Resources, in coordination with the California Water Commission, Bureau of Reclamation, State Water Resources Control Board, California Department of Public Health, the Delta Stewardship Council, and other agencies and stakeholders, should conduct a survey to identify projects throughout California that could be implemented within the next 5 to 10 years to expand existing surface and groundwater storage facilities, create new storage, improve operation of existing Delta conveyance*

POLICY OR RECOMMENDATION NUMBER	SHORT TITLE	POLICY/RECOMMENDATION LANGUAGE
		facilities, and enhance opportunities for conjunctive use programs and water transfers in furtherance of the coequal goals. The California Water Commission should hold hearings and provide recommendations to the California Department of Water Resources on priority projects and funding.
WR R15	Improve Water Transfer Procedures	*The California Department of Water Resources and the State Water Resources Control Board should work with stakeholders to identify and recommend measures to reduce procedural and administrative impediments to water transfers and protect water rights and environmental resources by December 31, 2016. These recommendations should include measures to address potential issues with recurring transfers of up to 1 year in duration and improved public notification for proposed water transfers.*
WR P2 (23 CCR section 5004)	Transparency in Water Contracting	*(a) The contracting process for water from the State Water Project and/or the Central Valley Project must be done in a publicly transparent manner consistent with applicable policies of the California Department of Water Resources and the Bureau of Reclamation referenced below.* *(b) For purposes of Water Code section 85057.5(a)(3) and section 5001(j)(1)(E) of this Chapter, this policy covers the following:* *(1) With regard to water from the State Water Project, a proposed action to enter into or amend a water supply or water transfer contract subject to California Department of Water Resources Guidelines 03-09 and/or 03-10 (each dated July 3, 2003), which are attached as Appendix 2A; and* *(2) With regard to water from the Central Valley Project, a proposed action to enter into or amend a water supply or water transfer contract subject to section 226 of P.L. 97-293, as amended or section 3405(a)(2)(B) of the Central Valley Project Improvement Act, Title XXXIV of Public Law 102-575, as amended, which are attached as Appendix 2B, and Rules and Regulations promulgated by the Secretary of the Interior to implement these laws.*
WR R16	Supplemental Water Use Reporting	*The State Water Resources Control Board should require water rights holders submitting supplemental statements of water diversion and use or progress reports under their permits or licenses to report on the development and implementation of all water efficiency and water supply projects and on their net (consumptive) use.*
WR R17	Integrated Statewide System for Water Use Reporting	*The California Department of Water Resources, in coordination with the State Water Resources Control Board, California Department of Public Health, California Public Utilities Commission, California Energy Commission, Bureau of Reclamation, California Urban Water Conservation Council, and other stakeholders, should develop a coordinated statewide system for water use reporting. This system should incorporate recommendations for inclusion of data needed to better manage California's water resources. The system should be designed to simplify reporting; reduce the number of required reports where possible; be made available to the public online; and be integrated with the reporting requirements for the urban water management plans, agricultural water management plans, and integrated regional water management plans. Water suppliers that export water from, transfer water through, or use water in the Delta watershed should be full participants in the data base.*

POLICY OR RECOMMENDATION NUMBER	SHORT TITLE	POLICY/RECOMMENDATION LANGUAGE
WR R18	California Water Plan	*The California Department of Water Resources, in consultation with the State Water Resources Control Board, and other agencies and stakeholders, should evaluate and include in the next and all future California Water Plan updates information needed to track water supply reliability performance measures identified in the Delta Plan, including an assessment of water efficiency and new water supply development, regional water balances, improvements in regional self-reliance, reduced regional reliance on the Delta, and reliability of Delta exports, and an overall assessment of progress in achieving the coequal goals.*
WR R19	Financial Needs Assessment	*As part of the California Water Plan Update, the California Department of Water Resources should prepare an assessment of the state's water infrastructure. This should include the costs of rehabilitating/replacing existing infrastructure, an assessment of the costs of new infrastructure, and an assessment of needed resources for monitoring and adaptive management for these projects. The California Department of Water Resources should also consider a survey of agencies that may be planning small-scale projects (such as storage or conveyance) that improve water supply reliability.*
Chapter 4		
ER P1 (23 CCR section 5005)	Delta Flow Objectives	*(a) The State Water Resources Control Board's Bay Delta Water Quality Control Plan flow objectives shall be used to determine consistency with the Delta Plan. If and when the flow objectives are revised by the State Water Resources Control Board, the revised flow objectives shall be used to determine consistency with the Delta Plan.* *(b) For purposes of Water Code section 85057.5(a)(3) and section 5001(j)(1)(E) of this Chapter, the policy set forth in subsection (a) covers a proposed action that could significantly affect flow in the Delta.*
ER R1	Update Delta Flow Objectives	*Development, implementation, and enforcement of new and updated flow objectives for the Delta and high-priority tributaries are key to the achievement of the coequal goals. The State Water Resources Control Board should update the Bay Delta Water Quality Control Plan objectives as follows:* *(a) By June 2, 2014, adopt and implement updated flow objectives for the Delta that are necessary to achieve the coequal goals.* *(b) By June 2, 2018, adopt, and as soon as reasonably possible, implement flow objectives for high-priority tributaries in the Delta watershed that are necessary to achieve the coequal goals.*[1] *Flow objectives could be implemented through several mechanisms including negotiation and settlement, Federal Energy Regulatory Commission relicensing, or adjudicative proceeding.*[2] *Prior to the establishment of revised flow objectives identified above, the existing Bay Delta Water Quality Control Plan objectives shall be used to determine consistency with the Delta Plan. After the flow objectives are revised, the revised objectives shall be used to determine consistency with the Delta Plan.*

[1] SWRCB staff should work with the Council and DFW to determine priority streams. As an illustrative example, priority streams could include the Merced River, Tuolumne River, Stanislaus River, Lower San Joaquin River, Deer Creek (tributary to Sacramento River), Lower Butte Creek, Mill Creek (tributary to Sacramento River), Cosumnes River, and American River. Implementation through hearings is expected to take longer than the deadline shown here.

[2] Implementation through adjudicative proceedings or FERC relicensing is expected to take longer than the deadline shown here.

POLICY OR RECOMMENDATION NUMBER	SHORT TITLE	POLICY/RECOMMENDATION LANGUAGE
ER P2 (23 CCR section 5006)	Restore Habitats at Appropriate Elevations	*(a) Habitat restoration must be carried out consistent with Appendix 3, which is Section II of the Draft Conservation Strategy for Restoration of the Sacramento-San Joaquin Delta Ecological Management Zone and the Sacramento and San Joaquin Valley Regions (California Department of Fish and Wildlife 2011). The elevation map attached as Appendix 4 should be used as a guide for determining appropriate habitat restoration actions based on an area's elevation. If a proposed habitat restoration action is not consistent with Appendix 4, the proposal shall provide rationale for the deviation based on best available science.* *(b) For purposes of Water Code section 85057.5(a)(3) and section 5001(j)(1)(E) of this Chapter, this policy covers a proposed action that includes habitat restoration.*
ER P3 (23 CCR section 5007)	Protect Opportunities to Restore Habitat	*(a) Within the priority habitat restoration areas depicted in Appendix 5, significant adverse impacts to the opportunity to restore habitat as described in section 5006, must be avoided or mitigated.* *(b) Impacts referenced in subsection (a) will be deemed to be avoided or mitigated if the project is designed and implemented so that it will not preclude or otherwise interfere with the ability to restore habitat as described in section 5006.* *(c) Impacts referenced in subsection (a) shall be mitigated to a point where the impacts have no significant effect on the opportunity to restore habitat as described in section 5006. Mitigation shall be determined, in consultation with the California Department of Fish and Wildlife, considering the size of the area impacted by the covered action and the type and value of habitat that could be restored on that area, taking into account existing and proposed restoration plans, landscape attributes, the elevation map shown in Appendix 4, and other relevant information about habitat restoration opportunities of the area.* *(d) For purposes of Water Code section 85057.5(a)(3) and section 5001(j)(1)(E) of this Chapter, this policy covers proposed actions in the priority habitat restoration areas depicted in Appendix 5. It does not cover proposed actions outside those areas.*
ER P4 (23 CCR section 5008)	Expand Floodplains and Riparian Habitats in Levee Projects	*(a) Levee projects must evaluate and where feasible incorporate alternatives, including the use of setback levees, to increase floodplains and riparian habitats. Evaluation of setback levees in the Delta shall be required only in the following areas (shown in Appendix 8): (1) The Sacramento River between Freeport and Walnut Grove, the San Joaquin River from the Delta boundary to Mossdale, Paradise Cut, Steamboat Slough, Sutter Slough; and the North and South Forks of the Mokelumne River, and (2) Urban levee improvement projects in the cities of West Sacramento and Sacramento.* *(b) For purposes of Water Code section 85057.5(a)(3) and section 5001(j)(1)(E) of this Chapter, this policy covers a proposed action to construct new levees or substantially rehabilitate or reconstruct existing levees.*
ER R2	Prioritize and Implement Projects that Restore Delta Habitat	*Bay Delta Conservation Plan implementers, California Department of Fish and Wildlife, California Department of Water Resources, and the Delta Conservancy should prioritize and implement habitat restoration projects in the areas shown on Figure 4-8. Habitat restoration projects should ensure connections between areas being restored and existing habitat areas and other elements of the landscape needed for the full life cycle of the species that will benefit from the restoration project.*

POLICY OR RECOMMENDATION NUMBER	SHORT TITLE	POLICY/RECOMMENDATION LANGUAGE
		Where possible, restoration projects should also emphasize the potential for improving water quality. Restoration project proponents should consult the California Department of Public Health's Best Management Practices for Mosquito Control in California*.* ▪ ***Yolo Bypass.*** *Enhance the ability of the Yolo Bypass to flood more frequently to provide more opportunities for migrating fish, especially Chinook salmon, to use this system as a migration corridor that is rich in cover and food.* ▪ ***Cache Slough Complex.*** *Create broad nontidal, freshwater, emergent-plant-dominated wetlands that grade into tidal freshwater wetlands, and shallow subtidal and deep open-water habitats. Also, return a significant portion of the region to uplands with vernal pools and grasslands.* ▪ ***Cosumnes River–Mokelumne River confluence.*** *Allow these unregulated and minimally regulated rivers to flood over their banks during winter and spring frequently and regularly to create seasonal floodplains and riparian habitats that grade into tidal marsh and shallow subtidal habitats.* ▪ ***Lower San Joaquin River floodplain.*** *Reconnect the floodplain and restore more natural flows to stimulate food webs that support native species. Integrate habitat restoration with flood management actions, when feasible.* ▪ ***Suisun Marsh.*** *Restore significant portions of Suisun Marsh to brackish marsh with land-water interactions to support productive, complex food webs to which native species are adapted and to provide space to adapt to rising sea level action. Use information from adaptive management processes during the Suisun Marsh Habitat Management, Preservation, and Restoration Plan's implementation to guide future habitat restoration projects and to inform future tidal marsh management.* ▪ ***Western Delta/Eastern Contra Costa County.*** *Restore tidal marsh and channel margin habitat at Dutch Slough and western islands to support food webs and provide habitat for native species.*
ER R3	Complete and Implement Delta Conservancy Strategic Plan	*As part of its Strategic Plan and subsequent Implementation Plan or annual work plans, the Delta Conservancy should:* ▪ *Develop and adopt criteria for prioritization and integration of large-scale ecosystem restoration in the Delta and Suisun Marsh, with sustainability and use of best available science as foundational principles.* ▪ *Develop and adopt processes for ownership and long-term operations and management of land in the Delta and Suisun Marsh acquired for conservation or restoration.* ▪ *Develop and adopt a formal mutual agreement with the California Department of Water Resources, California Department of Fish and Wildlife, federal interests, and other State and local agencies on implementation of ecosystem restoration in the Delta and Suisun Marsh.* ▪ *Develop, in conjunction with the Wildlife Conservation Board, the California Department of Water Resources, California Department of Fish and Wildlife, Bay Delta Conservation Plan implementers, and other State and local agencies, a plan and protocol for acquiring the land necessary to achieve ecosystem restoration consistent with the coequal goals and the Ecosystem Restoration Program Conservation Strategy.*

POLICY OR RECOMMENDATION NUMBER	SHORT TITLE	POLICY/RECOMMENDATION LANGUAGE
		▪ *Lead an effort, working with State and federal fish agencies, to investigate how to better use habitat credit agreements to provide credit for each of these steps: (1) acquisition for future restoration; (2) preservation, management, and enhancement of existing habitat; (3) restoration of habitat; and (4) monitoring and evaluation of habitat restoration projects.* ▪ *Work with the California Department of Fish and Wildlife and the U.S. Fish and Wildlife Service to develop rules for voluntary safe harbor agreements with property owners in the Delta whose actions contribute to the recovery of listed threatened or endangered species.*
ER R4	Exempt Delta Levees from the U.S. Army Corps of Engineers' Vegetation Policy	*Considering the ecosystem value of remaining riparian and shaded riverine aquatic habitat along Delta levees, the U.S. Army Corps of Engineers should agree with the California Department of Fish and Wildlife and the California Department of Water Resources on a variance that exempts Delta levees from the U.S. Army Corps of Engineers' levee vegetation policy where appropriate.*
ER R5	Update the Suisun Marsh Protection Plan	*The San Francisco Bay Conservation and Development Commission should update the Suisun Marsh Protection Plan and relevant components of the Suisun Marsh Local Protection Program to adapt to sea level rise and ensure consistency with the Suisun Marsh Preservation Act, the Delta Reform Act, and the Delta Plan.*
ER P5 (23 CCR section 5009)	Avoid Introductions of and Habitat Improvements for Invasive Nonnative Species	*(a) The potential for new introductions of or improved habitat conditions for nonnative invasive species, striped bass, or bass must be fully considered and avoided or mitigated in a way that appropriately protects the ecosystem.* *(b) For purposes of Water Code section 85057.5(a)(3) and section 5001(j)(1)(E) of this Chapter, this policy covers a proposed action that has the reasonable probability of introducing or improving habitat conditions for nonnative invasive species.*
ER R6	Regulate Angling for Nonnative Sport Fish to Protect Native Fish	*The California Department of Fish and Wildlife should develop, for consideration by the Fish and Game Commission, proposals for new or revised fishing regulations designed to increase populations of listed fish species through reduced predation by introduced sport fish. The proposals should be based on sound science that demonstrates these management actions are likely to achieve their intended outcome and include the development of performance measures and a monitoring plan to support adaptive management.*
ER R7	Prioritize and Implement Actions to Control Nonnative Invasive Species	*The California Department of Fish and Wildlife and other appropriate agencies should prioritize and fully implement the list of "Stage 2 Actions for Nonnative Invasive Species" and accompanying text shown in Appendix J taken from the* Conservation Strategy for Restoration of the Sacramento–San Joaquin Delta Ecological Management Zone and the Sacramento and San Joaquin Valley Regions *(DFG 2011). Implementation of the Stage 2 actions should include the development of performance measures and monitoring plans to support adaptive management.*
ER R8	Manage Hatcheries to Reduce Genetic Risk	*As required by the National Marine Fisheries Service, all hatcheries providing listed fish for release into the wild should continue to develop and implement scientifically sound Hatchery and Genetic Management Plans (HGMPs) to reduce risks to those species. The California Department of Fish and Wildlife should provide annual updates to the Delta Stewardship Council on the status of HGMPs within its jurisdiction.*

POLICY OR RECOMMENDATION NUMBER	SHORT TITLE	POLICY/RECOMMENDATION LANGUAGE
ER R9	Implement Marking and Tagging Program	*By December 2014, the California Department of Fish and Wildlife, in cooperation with the U.S. Fish and Wildlife Service and the National Marine Fisheries Service, should revise and begin implementing its program for marking and tagging hatchery salmon and steelhead to improve management of hatchery and wild stocks based on recommendations of the California Hatchery Scientific Review Group, which considered mass marking, reducing hatchery programs, and mark selective fisheries in developing its recommendations.*
Chapter 5		
DP R1	Designate the Delta as a National Heritage Area	*The Delta Protection Commission should complete its application for designation of the Delta and Suisun Marsh as a National Heritage Area, and the federal government should complete the process in a timely manner.*
DP R2	Designate State Route 160 as a National Scenic Byway	*The California Department of Transportation should seek designation of State Route 160 as a National Scenic Byway, and prepare and implement a scenic byway plan for it.*
DP P1 (23 CCR section 5010)	Locate New Urban Development Wisely	*(a) New residential, commercial, and industrial development must be limited to the following areas, as shown in Appendix 6 and Appendix 7:* *(1) Areas that city or county general plans as of May 16, 2013, designate for residential, commercial, and industrial development in cities or their spheres of influence;* *(2) Areas within Contra Costa County's 2006 voter-approved urban limit line, except no new residential, commercial, and industrial development may occur on Bethel Island unless it is consistent with the Contra Costa County general plan effective as of May 16, 2013;* *(3) Areas within the Mountain House General Plan Community Boundary in San Joaquin County; or* *(4) The unincorporated Delta towns of Clarksburg, Courtland, Hood, Locke, Ryde, and Walnut Grove.* *(b) Notwithstanding subsection (a), new residential, commercial, and industrial development is permitted outside the areas described in subsection (a) if it is consistent with the land uses designated in county general plans as of May 16, 2013, and is otherwise consistent with this Chapter.* *(c) For purposes of Water Code section 85057.5(a)(3) and section 5001(j)(1)(E) of this Chapter, this policy covers proposed actions that involve new residential, commercial, and industrial development that is not located within the areas described in subsection (a). In addition, this policy covers any such action on Bethel Island that is inconsistent with the Contra Costa County general plan effective as of May 16, 2013. This policy does not cover commercial recreational visitor-serving uses or facilities for processing of local crops or that provide essential services to local farms, which are otherwise consistent with this Chapter.* *(d) This policy is not intended in any way to alter the concurrent authority of the Delta Protection Commission to separately regulate development in the Delta's Primary Zone.*

POLICY OR RECOMMENDATION NUMBER	SHORT TITLE	POLICY/RECOMMENDATION LANGUAGE
DP P2 (23 CCR section 5011)	Respect Local Land Use When Siting Water or Flood Facilities or Restoring Habitats	*(a) Water management facilities, ecosystem restoration, and flood management infrastructure must be sited to avoid or reduce conflicts with existing uses or those uses described or depicted in city and county general plans for their jurisdictions or spheres of influence when feasible, considering comments from local agencies and the Delta Protection Commission. Plans for ecosystem restoration must consider sites on existing public lands, when feasible and consistent with a project's purpose, before privately owned sites are purchased. Measures to mitigate conflicts with adjacent uses may include, but are not limited to, buffers to prevent adverse effects on adjacent farmland.* *(b) For purposes of Water Code section 85057.5(a)(3) and section 5001(j)(1)(E) of this Chapter, this policy covers proposed actions that involve the siting of water management facilities, ecosystem restoration, and flood management infrastructure.*
DP R3	Plan for the Vitality and Preservation of Legacy Communities	*Local governments, in cooperation with the Delta Protection Commission and Delta Conservancy, should prepare plans for each community that emphasize its distinctive character, encourage historic preservation, identify opportunities to encourage tourism, serve surrounding lands, or develop other appropriate uses, and reduce flood risks.*
DP R4	Buy Rights of Way from Willing Sellers When Feasible	*Agencies acquiring land for water management facilities, ecosystem restoration, and flood management infrastructure should purchase from willing sellers, when feasible, including consideration of whether lands suitable for proposed projects are available at fair prices.*
DP R5	Provide Adequate Infrastructure	*The California Department of Transportation, local agencies, and utilities should plan infrastructure, such as roads and highways, to meet needs of development consistent with sustainable community strategies, local plans, the Delta Protection Commission's* Land Use and Resource Management Plan for the Primary Zone of the Delta*, and the Delta Plan.*
DP R6	Plan for State Highways	*The Delta Stewardship Council, as part of the prioritization of State levee investments called for in Water Code section 85306, should consult with the California Department of Transportation as provided in Water Code section 85307(c) to consider the effects of flood hazards and sea level rise on State highways in the Delta.*
DP R7	Subsidence Reduction and Reversal	*The following actions should be considered by the appropriate State agencies to address subsidence reversal:* ▪ *State agencies should not renew or enter into agricultural leases on Delta or Suisun Marsh islands if the actions of the lessee promote or contribute to subsidence on the leased land, unless the lessee participates in subsidence reversal or reduction programs.* ▪ *State agencies currently conducting subsidence reversal projects in the Delta on State-owned lands should investigate options for scaling up these projects if they have been deemed successful. The California Department of Water Resources should develop a plan, including funding needs, for increasing the extent of their subsidence reversal and carbon sequestration projects to 5,000 acres by January 1, 2017.* ▪ *The Delta Stewardship Council, in conjunction with the California Air Resources Board (CARB) and the Delta Conservancy, should investigate the opportunity for the development of a carbon market whereby Delta farmers could receive credit for carbon sequestration by reducing subsidence and growing native marsh and wetland plants. This investigation should include the potential for developing offset protocols applicable to these types of plants for subsequent adoption by the CARB.*

POLICY OR RECOMMENDATION NUMBER	SHORT TITLE	POLICY/RECOMMENDATION LANGUAGE
DP R8	Promote Value-added Crop Processing	*Local governments and economic development organizations, in cooperation with the Delta Protection Commission and the Delta Conservancy, should encourage value-added processing of Delta crops in appropriate locations.*
DP R9	Encourage Agritourism	*Local governments and economic development organizations, in cooperation with the Delta Protection Commission and the Delta Conservancy, should support growth in agritourism, particularly in and around legacy communities. Local plans should support agritourism where appropriate.*
DP R10	Encourage Wildlife-friendly Farming	*The California Department of Fish and Wildlife, the Delta Conservancy, and other ecosystem restoration agencies should encourage habitat enhancement and wildlife-friendly farming systems on agricultural lands to benefit both the environment and agriculture.*
DP R11	Provide New and Protect Existing Recreation Opportunities	*Water management and ecosystem restoration agencies should provide recreation opportunities, including visitor-serving business opportunities, at new facilities and habitat areas whenever feasible; and existing recreation facilities should be protected, using California State Parks'* Recreation Proposal for the Sacramento-San Joaquin Delta and Suisun Marsh *and Delta Protection Commission's* Economic Sustainability Plan for the Sacramento-San Joaquin Delta *as guides.*
DP R12	Encourage Partnerships to Support Recreation and Tourism	*The Delta Protection Commission and Delta Conservancy should encourage partnerships between other State and local agencies, and local landowners and business people to expand recreation, including boating, promote tourism, and minimize adverse impacts to nonrecreational landowners.*
DP R13	Expand State Recreation Areas	*California State Parks should add or improve recreation facilities in the Delta in cooperation with other agencies. As funds become available, it should fully reopen Brannan Island State Recreation Area, complete the park at Delta Meadows-Locke Boarding House, and consider adding new State parks at Barker Slough, Elkhorn Basin, the Wright-Elmwood Tract, and south Delta.*
DP R14	Enhance Nature-based Recreation	*The California Department of Fish and Wildlife, in cooperation with other public agencies, should collaborate with nonprofits, private landowners, and business partners to expand wildlife viewing, angling, and hunting opportunities.*
DP R15	Promote Boating Safety	*The California Department of Boating and Waterways should coordinate with the U.S. Coast Guard and State and local agencies on an updated marine patrol strategy for the region.*
DP R16	Encourage Recreation on Public Lands	*Public agencies owning land should increase opportunities, where feasible, for bank fishing, hunting, levee-top trails, and environmental education.*
DP R17	Enhance Opportunities for Visitor-serving Businesses	*Cities, counties, and other local and State agencies should work together to protect and enhance visitor-serving businesses by planning for recreation uses and facilities in the Delta, providing infrastructure to support recreation and tourism, and identifying settings for private visitor-serving development and services.*
DP R18	Support the Ports of Stockton and West Sacramento	*The ports of Stockton and West Sacramento should encourage maintenance and carefully designed and sited development of port facilities.*

POLICY OR RECOMMENDATION NUMBER	SHORT TITLE	POLICY/RECOMMENDATION LANGUAGE
DP R19	Plan for Delta Energy Facilities	*The California Energy Commission and California Public Utilities Commission should cooperate with the Delta Stewardship Council as described in Water Code section 85307(d) to identify actions that should be incorporated in the Delta Plan by 2017 to address the needs of Delta energy development, storage, and distribution.*
Chapter 6		
WQ R1	Protect Beneficial Uses	*Water quality in the Delta should be maintained at a level that supports, enhances, and protects beneficial uses identified in the applicable State Water Resources Control Board or regional water quality control board water quality control plans.*
WQ R2	Identify Covered Action Impacts	*Covered actions should identify any significant impacts to water quality.*
WQ R3	Special Water Quality Protections for the Delta	*The State Water Resources Control Board or regional water quality control board should evaluate and, if appropriate, propose special water quality protections for priority habitat restoration areas identified in recommendation ER R2 or other areas of the Delta where new or increased discharges of pollutants could adversely impact beneficial uses.*
WQ R4	Complete Central Valley Drinking Water Policy	*The Central Valley Regional Water Quality Control Board should complete the Central Valley Drinking Water Policy by July 2013.*
WQ R5	Complete North Bay Aqueduct Alternative Intake Project	*The California Department of Water Resources should complete the North Bay Aqueduct Alternate Intake Project Environmental Impact Report by December 31, 2012, and begin construction as soon as possible thereafter.*
WQ R6	Protect Groundwater Beneficial Uses	*The State Water Resources Control Board should complete development of a Strategic Workplan for protection of groundwater beneficial uses, including groundwater use for drinking water, by December 31, 2012.*
WQ R7	Participation in CV-SALTS	*The State Water Resources Control Board and Central Valley Regional Water Quality Control Board should consider requiring participation by all relevant water users that are supplied water from the Delta or the Delta watershed or discharge wastewater to the Delta or the Delta watershed to participate in the Central Valley Salinity Alternatives for Long-Term Sustainability Program.*
WQ R8	Completion of Regulatory Processes, Research, and Monitoring for Water Quality Improvement	*The State Water Resources Control Board and the San Francisco Bay and Central Valley Regional Water Quality Control Boards are currently engaged in regulatory processes, research, and monitoring essential to improving water quality in the Delta. In order to achieve the coequal goals, it is essential that these ongoing efforts be completed and, if possible, accelerated, and that the Legislature and Governor devote sufficient funding to make this possible. The Delta Stewardship Council specifically recommends that:* ▪ *The State Water Resources Control Board should complete development of the proposed policy for nutrients for inland surface waters of the State of California by January 1, 2014.* ▪ *The State Water Resources Control Board and the San Francisco Bay and Central Valley Regional Water Quality Control Boards should prepare and begin implementation of a study plan for the development of objectives for nutrients in the Delta and Suisun Marsh by January 1, 2014. Studies needed for development of Delta and Suisun Marsh nutrient objectives should be completed by January 1, 2016. The water boards should*

POLICY OR RECOMMENDATION NUMBER	SHORT TITLE	POLICY/RECOMMENDATION LANGUAGE
		adopt and begin implementation of nutrient objectives, either narrative or numeric, where appropriate, for the Delta and Suisun Marsh by January 1, 2018. ▪ *The State Water Resources Control Board and the Central Valley Regional Water Quality Control Board should complete the Central Valley Pesticide Total Maximum Daily Load and Basin Plan Amendment for diazinon and chlorpyrifos by January 1, 2013.* ▪ *The State Water Resources Control Board and the Central Valley Regional Water Quality Control Board should prioritize and accelerate the completion of the Central Valley Pesticide Total Maximum Daily Load and Basin Plan Amendment for pyrethroids by January 1, 2016.* ▪ *The State Water Resources Control Board and the San Francisco Bay and Central Valley Regional Water Quality Control Boards have completed Total Maximum Daily Load and Basin Plan Amendments for methylmercury, and efforts to support their implementation should be coordinated. Parties identified as responsible for current methylmercury loads or proponents of projects that may increase methylmercury loading in the Delta or Suisun Marsh should participate in control studies or implement site-specific study plans that evaluate practices to minimize methylmercury discharges. The Central Valley Regional Water Quality Control Board should review these control studies by December 31, 2018, and determine control measures for implementation starting in 2020.*
WQ R9	Implement Delta Regional Monitoring Program	*The State Water Resources Control Board and Regional Water Quality Control Boards should work collaboratively with the California Department of Water Resources, California Department of Fish and Wildlife, and other agencies and entities that monitor water quality in the Delta to develop and implement a Delta Regional Monitoring Program that will be responsible for coordinating monitoring efforts so Delta conditions can be efficiently assessed and reported on a regular basis.*
WQ R10	Evaluate Wastewater Recycling, Reuse, or Treatment	*The Central Valley Regional Water Quality Control Board, consistent with existing water quality control plan policies and water rights law, should require responsible entities that discharge wastewater treatment plant effluent or urban runoff to Delta waters to evaluate whether all or a portion of the discharge can be recycled, otherwise used, or treated in order to reduce contaminant loads to the Delta by January 1, 2014.*
WQ R11	Manage Dissolved Oxygen in Stockton Ship Channel	*The State Water Resources Control Board and the Central Valley Regional Water Quality Control Board should complete Phase 2 of the Total Maximum Daily Load and Basin Plan Amendment for dissolved oxygen in the Stockton Deep Water Ship Channel by January 1, 2015.*
WQ R12	Manage Dissolved Oxygen in Suisun Marsh	*The State Water Resources Control Board and the San Francisco Bay Regional Water Quality Control Board should complete the Total Maximum Daily Load and Basin Plan Amendment for dissolved oxygen in Suisun Marsh wetlands by January 1, 2014.*

<table>
<tr><th>POLICY OR RECOMMENDATION NUMBER</th><th>SHORT TITLE</th><th>POLICY/RECOMMENDATION LANGUAGE</th></tr>
<tr><td colspan="3">Chapter 7</td></tr>
<tr><td>RR R1</td><td>Implement Emergency Preparedness and Response</td><td>The following actions should be taken by January 1, 2014, to promote effective emergency preparedness and response in the Delta:
Responsible local, State, and federal agencies with emergency response authority should consider and implement the recommendations of the Sacramento-San Joaquin Delta Multi-Hazard Coordination Task Force (Water Code section 12994.5). Such actions should support the development of a regional response system for the Delta.
In consultation with local agencies, the California Department of Water Resources should expand its emergency stockpiles to make them regional in nature and usable by a larger number of agencies in accordance with California Department of Water Resources' plans and procedures. The California Department of Water Resources, as a part of this plan, should evaluate the potential of creating stored material sites by "over-reinforcing" west Delta levees.
Local levee-maintaining agencies should consider developing their own emergency action plans, and stockpiling rock and flood-fighting materials.
State and local agencies and regulated utilities that own and/or operate infrastructure in the Delta should prepare coordinated emergency response plans to protect the infrastructure from long-term outages resulting from failures of the Delta levees. The emergency procedures should consider methods that also would protect Delta land use and ecosystem.</td></tr>
<tr><td>RR R2</td><td>Finance Local Flood Management Activities</td><td>The Legislature should create a Delta Flood Risk Management Assessment District with fee assessment authority (including over State infrastructure) to provide adequate flood control protection and emergency response for the regional benefit of all beneficiaries, including landowners, infrastructure owners, and other entities that benefit from the maintenance and improvement of Delta levees, such as water users who rely on the levees to protect water quality.
This district should be authorized to:
Identify and assess all beneficiaries of Delta flood protection facilities.
Develop, fund, and implement a regional plan of flood management for both project and nonproject levees of the Delta, including the maintenance and improvement of levees, in cooperation with the existing reclamation districts, cities, counties, and owners of infra-structure and other interests protected by the levees.
Require local levee-maintaining agencies to conduct annual levee inspections per the California Department of Water Resources subventions program guidelines, and update levee improvement plans every 5 years.
Participate in the collection of data and information necessary for the prioritization of State investments in Delta levees consistent with RR P1.
Notify residents and landowners of flood risk, personal safety information, and available systems for obtaining emergency information before and during a disaster on an annual basis.
Potentially implement the recommendations of the Sacramento-San Joaquin Delta Multi-Hazard Coordination Task Force (Water Code section 12994.5) in conjunction with local, State, and federal agencies, and maintain the resulting regional response system</td></tr>
</table>

POLICY OR RECOMMENDATION NUMBER	SHORT TITLE	POLICY/RECOMMENDATION LANGUAGE
		and components and procedures on behalf of SEMS jurisdictions (reclamation district, city, county, and State) that would jointly implement the regional system in response to a disaster event. ▪ *Identify and assess critical water supply corridor levee operations, maintenance, and improvements.*
RR R3	Fund Actions to Protect Infrastructure from Flooding and Other Natural Disasters	▪ *The California Public Utilities Commission should immediately commence formal hearings to impose a reasonable fee for flood and disaster prevention on regulated privately owned utilities with facilities located in the Delta. Publicly owned utilities should also be encouraged to develop similar fees. The California Public Utilities Commission, in consultation with the Delta Stewardship Council, the California Department of Water Resources, and the Delta Protection Commission, should allocate these funds among State and local emergency response and flood protection entities in the Delta. If a new regional flood management agency is established by law, a portion of the local share would be allocated to that agency.* ▪ *The California Public Utilities Commission should direct all regulated public utilities in their jurisdiction to immediately take steps to protect their facilities in the Delta from the consequences of a catastrophic failure of levees in the Delta, to minimize the impact on the State's economy.* ▪ *The Governor, by Executive Order, should direct State agencies with projects or infrastructure in the Delta to set aside a reasonable amount of funding to pay for flood protection and disaster prevention. The local share of these funds should be allocated as described above.*
RR P1 (23 CCR section 5012)	Prioritization of State Investments in Delta Levees and Risk Reduction	*(a) Prior to the completion and adoption of the updated priorities developed pursuant to Water Code section 85306, the interim priorities listed below shall, where applicable and to the extent permitted by law, guide discretionary State investments in Delta flood risk management. Key priorities for interim funding include emergency preparedness, response, and recovery as described in paragraph (1), as well as Delta levees funding as described in paragraph (2).* *(1) Delta Emergency Preparedness, Response, and Recovery: Develop and implement appropriate emergency preparedness, response, and recovery strategies, including those developed by the Delta Multi-Hazard Task Force pursuant to Water Code section 12994.5.* *(2) Delta Levees Funding: The priorities shown in the following table are meant to guide budget and funding allocation strategies for levee improvements. The goals for funding priorities are all important, and it is expected that over time, the California Department of Water Resources must balance achievement of those goals. Except on islands planned for ecosystem restoration, improvement of nonproject Delta levees to the Hazard Mitigation Plan (HMP) standard may be funded without justification of the benefits. Improvements to a standard above HMP, such as that set by the U.S. Army Corps of Engineers under Public Law 84-99, may be funded as befits the benefits to be provided, consistent with the California Department of Water Resources' current practices and any future adopted investment strategy.*

POLICY OR RECOMMENDATION NUMBER	SHORT TITLE	POLICY/RECOMMENDATION LANGUAGE

Priorities for State Investment in Delta Integrated Flood Management

Categories of Benefit Analysis

Goals	Localized Flood Protection	Levee Network	Ecosystem Conservation
1	Protect existing urban and adjacent urbanizing areas by providing 200-year flood protection.	Protect water quality and water supply conveyance in the Delta, especially levees that protect freshwater aqueducts and the primary channels that carry fresh water through the Delta.	Protect existing and provide for a net increase in channel-margin habitat.
2	Protect small communities and critical infrastructure of statewide importance (located outside of urban areas).	Protect floodwater conveyance in and through the Delta to a level consistent with the State Plan of Flood Control for project levees.	Protect existing and provide for net enhancement of floodplain habitat.
3	Protect agriculture and local working landscapes.	Protect cultural, historic, aesthetic, and recreational resources (Delta as Place).	Protect existing and provide for net enhancement of wetlands.

(b) For purposes of Water Code section 85057.5(a)(3) and section 5001(j)(1)(E) of this Chapter, this policy covers a proposed action that involves discretionary State investments in Delta flood risk management, including levee operations, maintenance, and improvements. Nothing in this policy establishes or otherwise changes existing levee standards.

POLICY OR RECOMMENDATION NUMBER	SHORT TITLE	POLICY/RECOMMENDATION LANGUAGE
RR R4	Actions for the Prioritization of State Investments in Delta Levees	*The Delta Stewardship Council, in consultation with the California Department of Water Resources, the Central Valley Flood Protection Board, the Delta Protection Commission, local agencies, and the California Water Commission, should develop funding priorities for State investments in Delta levees by January 1, 2015. These priorities shall be consistent with the provisions of the Delta Reform Act in promoting effective, prioritized strategic State investments in levee operations, maintenance, and improvements in the Delta for both levees that are a part of the State Plan of Flood Control and nonproject levees. Upon completion, these priorities shall be considered for incorporation into the Delta Plan.* *The priorities should identify guiding principles, constraints, recommended cost share allocations, and strategic considerations to guide Delta flood risk reduction investments,*

POLICY OR RECOMMENDATION NUMBER	SHORT TITLE	POLICY/RECOMMENDATION LANGUAGE

		supported by, at a minimum, the following actions to be conducted by the California Department of Water Resources, consistent with available funding:
		▪ *An assessment of existing Delta levee conditions. This should include the development of a Delta levee conditions map based on sound data inputs, including, but not limited to:*
		  ▪ *Geometric levee assessment*
		  ▪ *Flow and updated stage-frequency analysis*
		▪ *An island-by-island economics-based risk analysis. This analysis should consider, but not be limited to, values related to protecting:*
		  ▪ *Island residents/life safety*
		  ▪ *Property*
		  ▪ *Value of Delta islands' economic output, including agriculture*
		  ▪ *State water supply*
		  ▪ *Critical local, State, federal, and private infrastructure, including aqueducts, state highways, electricity transmission lines, gas/petroleum pipelines, gas fields, railroads, and deep water shipping channels*
		  ▪ *Delta water quality*
		  ▪ *Existing ecosystem values and ecosystem restoration opportunities*
		  ▪ *Recreation*
		  ▪ *Systemwide integrity*
		▪ *An ongoing assessment of Delta levee conditions. This should include a process for updating Delta levee assessment information on a routine basis.*
		This methodology should provide the basis for the prioritization of State investments in Delta levees. It should include, but not be limited to, the public reporting of the following items:
		▪ *Tiered ranking of Delta islands, based on economics-based risk analysis values*
		▪ *Delta levee conditions status report, including a levee conditions map*
		▪ *Inventory of Delta infrastructure assets*

RR P2 (23 CCR section 5013)	Require Flood Protection for Residential Development in Rural Areas	*(a) New residential development of five or more parcels shall be protected through flood-proofing to a level 12 inches above the 100-year base flood elevation, plus sufficient additional elevation to protect against a 55-inch rise in sea level at the Golden Gate, unless the development is located within:* *(1) Areas that city or county general plans, as of May 16, 2013, designate for development in cities or their spheres of influence;* *(2) Areas within Contra Costa County's 2006 voter-approved urban limit line, except Bethel Island;* *(3) Areas within the Mountain House General Plan Community Boundary in San Joaquin County; or* *(4) The unincorporated Delta towns of Clarksburg, Courtland, Hood, Locke, Ryde, and Walnut Grove, as shown in Appendix 7.* *(b) For purposes of Water Code section 85057.5(a)(3) and section 5001(j)(1)(E) of this Chapter, this policy covers a proposed action that involves new residential development of five or more parcels that is not located within the areas described in subsection (a).*

POLICY OR RECOMMENDATION NUMBER	SHORT TITLE	POLICY/RECOMMENDATION LANGUAGE
RR P3 (23 CCR section 5014)	Protect Floodways	*(a) No encroachment shall be allowed or constructed in a floodway, unless it can be demonstrated by appropriate analysis that the encroachment will not unduly impede the free flow of water in the floodway or jeopardize public safety.* *(b) For purposes of Water Code section 85057.5(a)(3) and section 5001(j)(1)(E) of this Chapter, this policy covers a proposed action that would encroach in a floodway that is not either a designated floodway or regulated stream.*
RR P4 (23 CCR section 5015)	Floodplain Protection	*(a) No encroachment shall be allowed or constructed in any of the following floodplains unless it can be demonstrated by appropriate analysis that the encroachment will not have a significant adverse impact on floodplain values and functions:* *(1) The Yolo Bypass within the Delta;* *(2) The Cosumnes River-Mokelumne River Confluence, as defined by the North Delta Flood Control and Ecosystem Restoration Project (McCormack-Williamson), or as modified in the future by the California Department of Water Resources or the U.S. Army Corps of Engineers (California Department of Water Resources 2010); and* *(3) The Lower San Joaquin River Floodplain Bypass area, located on the Lower San Joaquin River upstream of Stockton immediately southwest of Paradise Cut on lands both upstream and downstream of the Interstate 5 crossing. This area is described in the Lower San Joaquin River Floodplain Bypass Proposal, submitted to the California Department of Water Resources by the partnership of the South Delta Water Agency, the River Islands Development Company, Reclamation District 2062, San Joaquin Resource Conservation District, American Rivers, the American Lands Conservancy, and the Natural Resources Defense Council, March 2011. This area may be modified in the future through the completion of this project.* *(b) For purposes of Water Code section 85057.5(a)(3) and section 5001(j)(1)(E) of this Chapter, this policy covers a proposed action that would encroach in any of the floodplain areas described in subsection (a).* *(c) This policy is not intended to exempt any activities in any of the areas described in subsection (a) from applicable regulations and requirements of the Central Valley Flood Protection Board.*
RR R5	Fund and Implement San Joaquin River Flood Bypass	*The Legislature should fund the California Department of Water Resources and the Central Valley Flood Protection Board to evaluate and implement a bypass and floodway on the San Joaquin River near Paradise Cut that would reduce flood stage on the mainstem San Joaquin River adjacent to the urban and urbanizing communities of Stockton, Lathrop, and Manteca in accordance with Water Code section 9613(c).*
RR R6	Continue Delta Dredging Studies	*The current efforts to maintain navigable waters in the Sacramento River Deep Water Ship Channel and Stockton Deep Water Ship Channel, led by the U.S. Army Corps of Engineers and described in the Delta Dredged Sediment Long-Term Management Strategy (USACE 2007, Appendix K), should be continued in a manner that supports the Delta Plan and the coequal goals. Appropriate dredging throughout other areas in the Delta for maintenance purposes, or that would increase flood conveyance and provide potential material for levee maintenance or subsidence reversal should be implemented in a manner that supports the Delta Plan and coequal goals. Coordinated use of dredged material in levee improvement, subsidence reversal, or wetland restoration is encouraged.*

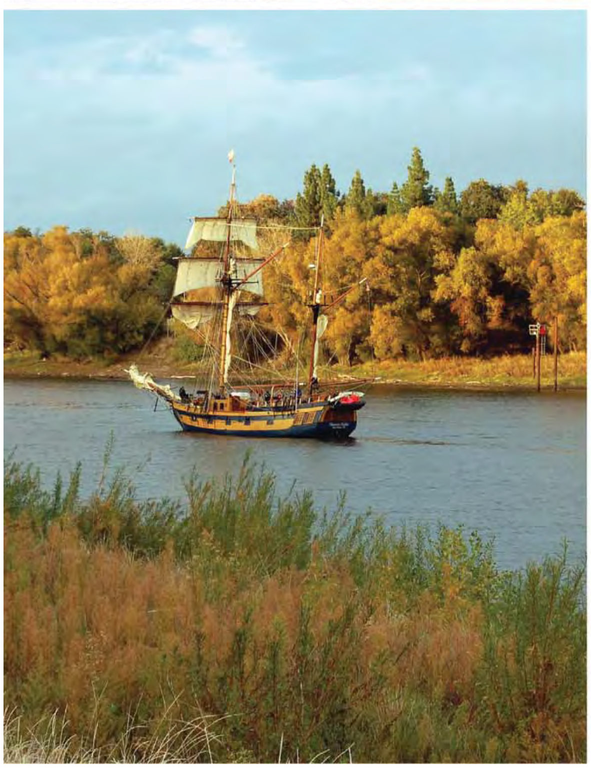
POLICY OR RECOMMENDATION NUMBER	SHORT TITLE	POLICY/RECOMMENDATION LANGUAGE
RR R7	Designate Additional Floodways	*The Central Valley Flood Protection Board should evaluate whether additional areas both within and upstream of the Delta should be designated as floodways. These efforts should consider the anticipated effects of climate change in its evaluation of these areas.*
RR R8	Develop Setback Levee Criteria	*The California Department of Water Resources, in conjunction with the Central Valley Flood Protection Board, the California Department of Fish and Wildlife, and the Delta Conservancy, should develop criteria to define locations for future setback levees in the Delta and Delta watershed.*
RR R9	Require Flood Insurance	*The Legislature should require an adequate level of flood insurance for residences, businesses, and industries in floodprone areas.*
RR R10	Limit State Liability	*The Legislature should consider statutory and/or constitutional changes that would address the State's potential flood liability, including giving State agencies the same level of immunity with regard to flood liability as federal agencies have under federal law.*
Chapter 8		
FP R1	Conduct Current Spending Inventory	*An inventory of current State and federal spending on programs and projects that do or may achieve the coequal goals will be conducted. Data sources to be used include the CALFED cross-cut budget, State bond balance reports, and the annual State budget, among others. Consideration will be given to selecting an independent agency (which could include a non governmental organization) to conduct the inventory.*
FP R2	Develop Delta Plan Cost Assessment	*Costs will be assigned to the projects and programs proposed in the Delta Plan (Chapters 2 through 7) and sources of funding will be identified.*
FP R3	Identify Funding Gaps	*Current State and federal funding gaps will be identified that are determined to hinder progress toward meeting the coequal goals.*

This page intentionally left blank.

CHAPTER 1

Introduction






ABOUT THIS CHAPTER

This chapter offers historical and current contextual information about the uses and conflicts that besiege the Sacramento-San Joaquin Delta (Delta). The reader will come to understand how and why the West Coast's largest estuary has evolved from a huge tidal marsh to the maze of islands and channels it is today – shaped over more than a century and a half by the effects of hydraulic mining, flood control, agricultural and urban development, and its placement as the "hub" of California's major water systems.

The chapter then delves into the realities of decades of stand-offs among the key interests in the Delta and resulting years of relative inaction, leading finally to the bipartisan movement that created the Sacramento-San Joaquin Delta Reform Act of 2009 (Delta Reform Act or Act) and its mandate to develop a long-term sustainable management plan for the Delta. The chapter concludes with an overarching explanation of how this Delta Plan (or Plan) will bring about a fundamental and positive sustainability and reformation of this immense natural resource.

CHAPTER 1

Introduction

Throughout the past 160 years, the delta formed by California's two largest rivers, the Sacramento and the San Joaquin, has been a gateway to many of the state's collective hopes and dreams. Once the pathway to the Gold Country, it is today a critical component of the state's water supply infrastructure, a source of sustenance for farmers and fishermen, and home to half a million people and a vast array of fish, birds, and wildlife.

The Sacramento-San Joaquin Delta and Suisun Marsh are referred to throughout this Plan collectively as "the Delta," unless otherwise specified (see Figure 1-1).[1] Once a great marsh, the Delta now is a network of channels and sunken "islands" that cover—together with Suisun Marsh—about 1,300 square miles. Laid over those islands and channels is the infrastructure of a twenty-first century economy: water supply conduits; major arteries of the state's electrical grid; natural gas fields, storage facilities, and pipelines; highways and railways; and shipping channels, all surrounded by an increasingly urban landscape. Water from the vast Delta watershed, spanning over 45,000 square miles (30 million acres), fuels both local economies and those in export areas hundreds of miles away (see Figure 1-2).

Today the Delta is many things to many people, and is universally regarded in "crisis" because people have not yet been able to find balance in the tradeoffs among competing demands for the Delta's resources. Tradeoffs and integration define the Delta dilemma: water conveyance facilities that built strong urban and agricultural economies threaten ecosystem health. Water that is beneficial for fish is alive with plankton and organic material, but sources of drinking water are best in as pure a form as possible. The pollutants of upstream urban and agricultural uses cause problems for downstream fish and water diverters alike. The same ocean-going ships that opened the Central Valley to world trade also introduced nonnative species that alter the Delta ecosystem. High water flows that historically improved habitat and a diverse food web come with the threat of lost homes, flooded farmland, and disaster for Delta residents and the California economy.

Conceived decades ago, a series of water projects has engineered the Delta estuary over time to perform as a water conveyance system, moving water stored upstream to users throughout the state who hold State of California (State) or federal water contracts. This system relies on dredged channels, which at times run counter to natural flow directions as the result of export pumping that occurs in the south Delta. For a number of years, and currently at the publishing time of this Plan, State and federal agencies are exploring options to reconfigure the manner in which the Delta is used to convey water in a way that lessens ecosystem impacts and improves water supply reliability. At this time, the Delta Plan does not make recommendations regarding Delta conveyance (see Appendix A).

As a result of imperfect tradeoffs, key species are endangered or threatened, the amount of water that can be exported from the Delta is determined not just by the state's variable precipitation and storage but also by court order to protect endangered species, and geologists and engineers continue to worry that the Delta itself is one of the greatest flood risks in the West.

[1] The Sacramento-San Joaquin Delta is defined in Water Code section 12220, and Suisun Marsh means the area defined in Public Resources Code section 29101 and protected by Division 19 (commencing with section 29000).

The evolution of the Delta has come in fits and starts, driven by individual initiative, governmental incentive, and crisis. John Hart, writing for *Bay-Nature*, puts it this way:

> *The History of the modern Delta belies the image of the region as a static landscape. Reclamation was a battle with many setbacks, almost given up for lost in the 1870s. In the 1880s the 'crisis' was the clogging of channels by hydraulic mining debris. In the 1920s, salinity was on the march. A brief calm at midcentury gave way to the ever-spiraling tension over water exports and ecosystem decline. The Delta seems always to have been in crisis, under intensive study, and at the intersection of hostile interests.*

Governmental institutions have reacted to each crisis predictably, often treating individual problems rather than taking a systemwide approach. Over the years, dozens of agencies, task forces, and working groups have been created in a series of sometimes overlapping efforts to find the right combination of leadership and collaboration—incentives and regulation—to provide clean, reliable water; protect our environment; and reduce the risk of flooding.

After decades of conflict and unsuccessful efforts to comprehensively address the many problems and challenges of the Delta, the California Legislature (or Legislature), water agencies, and environmental groups throughout the state united in an unprecedented manner in 2009 to pass a series of water-related measures, including the Delta Reform Act.

The Delta Reform Act created the Delta Stewardship Council (Council) with a primary responsibility to develop and implement a legally enforceable, long-term management plan for the Delta. The Legislature required the Delta Plan to advance the coequal goals of protecting and enhancing the Delta ecosystem and providing for a more reliable water supply for California, and to do so in a manner that protects and enhances the Delta as an evolving place.

This Delta Plan is intended to be a foundational document that prioritizes actions and strategies in support of key objectives such as the State's requirement to reduce reliance on the Delta to meet future water supply needs. It also restricts actions that may cause harm; serves as a guidebook for all plans, projects, and programs that affect the Delta; and calls for further investigation and focused study of specific issues.

Successful implementation of the Delta Plan depends not only on the Council, but also on coordinated actions by other government agencies—federal, State, and local—and by the stakeholders to whom these agencies are responsible. To be effective, decision making in a dynamic context such as the Delta must be flexible and have the capacity to change policies and practices in response to what is learned over time. Through this Delta Plan, the Council details an interagency structure for decision making that fosters communication among scientists; local, State, and federal decision makers; and stakeholders. Future Plan iterations will build on successes as well as lessons learned in order to achieve the coequal goals.

The Delta and California's Water Supply

The story of California's annual water supply is one of great variability in amount, timing, and distribution, and of the human desire to impose certainty and order. Rain and snow fall mostly in the northern and eastern portions of the state, but most Californians live along the coast and in the south. Most of the state's precipitation occurs in only 5 to 15 days, and that rain and snowfall result in an annual supply that is ample in average years, too little in dry ones, and too much in wet years (see Figure 1-3).

The Sacramento-San Joaquin Delta and Suisun Marsh

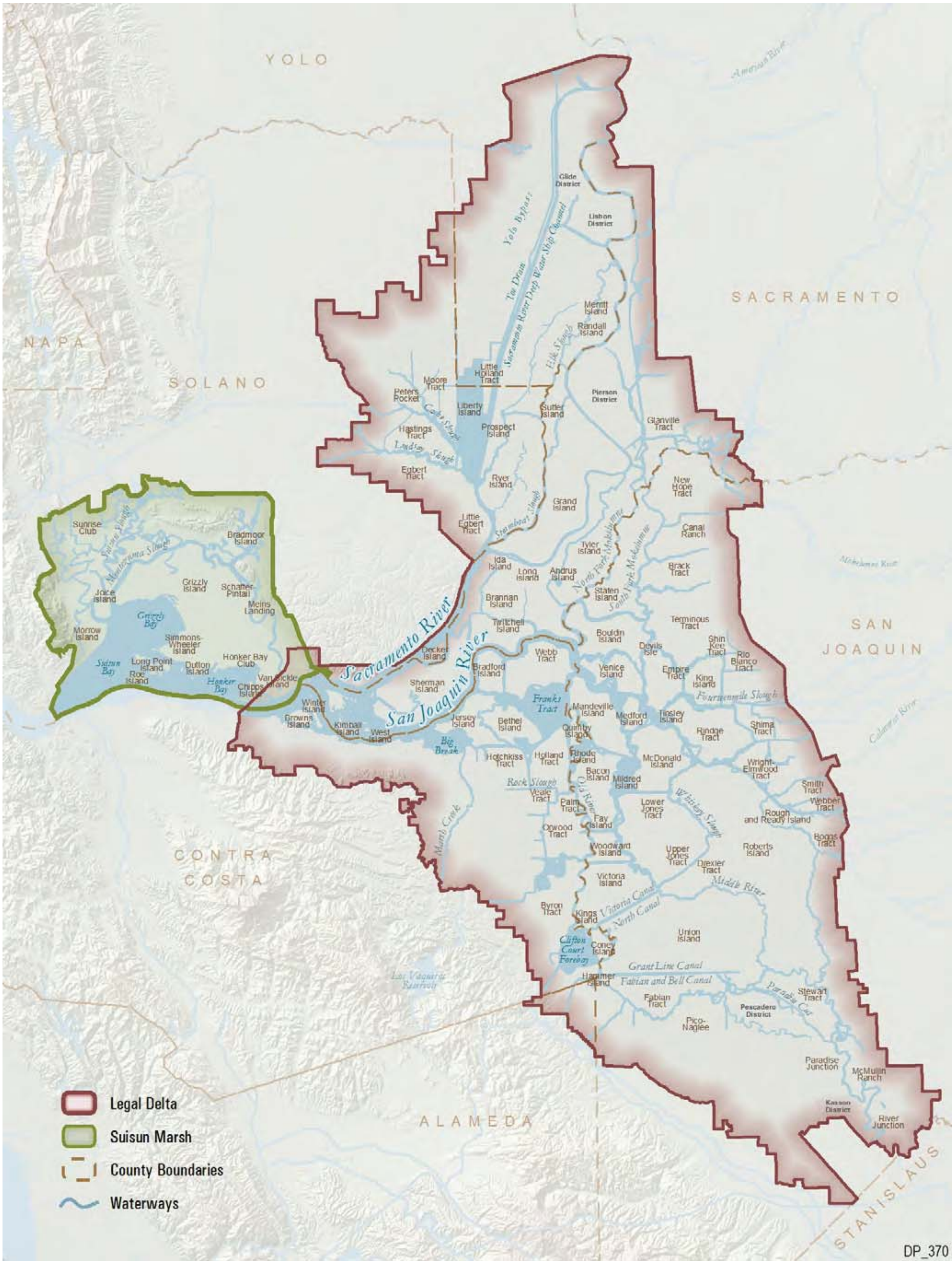


Figure 1-1 *Source: DWR 2011a*

The Delta Watershed and Areas Receiving Delta Water

Figure 1-2

To meet water demand, Californians over the past 160 years have built a vast array of reservoirs, canals, pipelines, and tunnels, all in an effort to capture water when it was available, store it for when it was not, and to move it to the people when and where they wanted it.

As residents in both Northern and Southern California feared they would outgrow their local supplies, they turned to the vast Delta watershed for relief. The river systems flowing into the Delta drain about 40 percent of the land in California and carry about half of the state's total annual runoff.

And so, at the turn of the twentieth century, San Francisco tapped the Tuolumne River, diverting water through an aqueduct that bypasses the San Joaquin River and Delta. Shortly thereafter, Oakland and the eastern San Francisco Bay Area tapped the Mokelumne River, diverting water through a pipeline across the Delta. Later, construction of the federal Central Valley Project (CVP) and the State Water Project (SWP) resulted in additional diversions directly from the Delta for the Bay Area, Central Valley, and Southern California.

California's Variable Precipitation

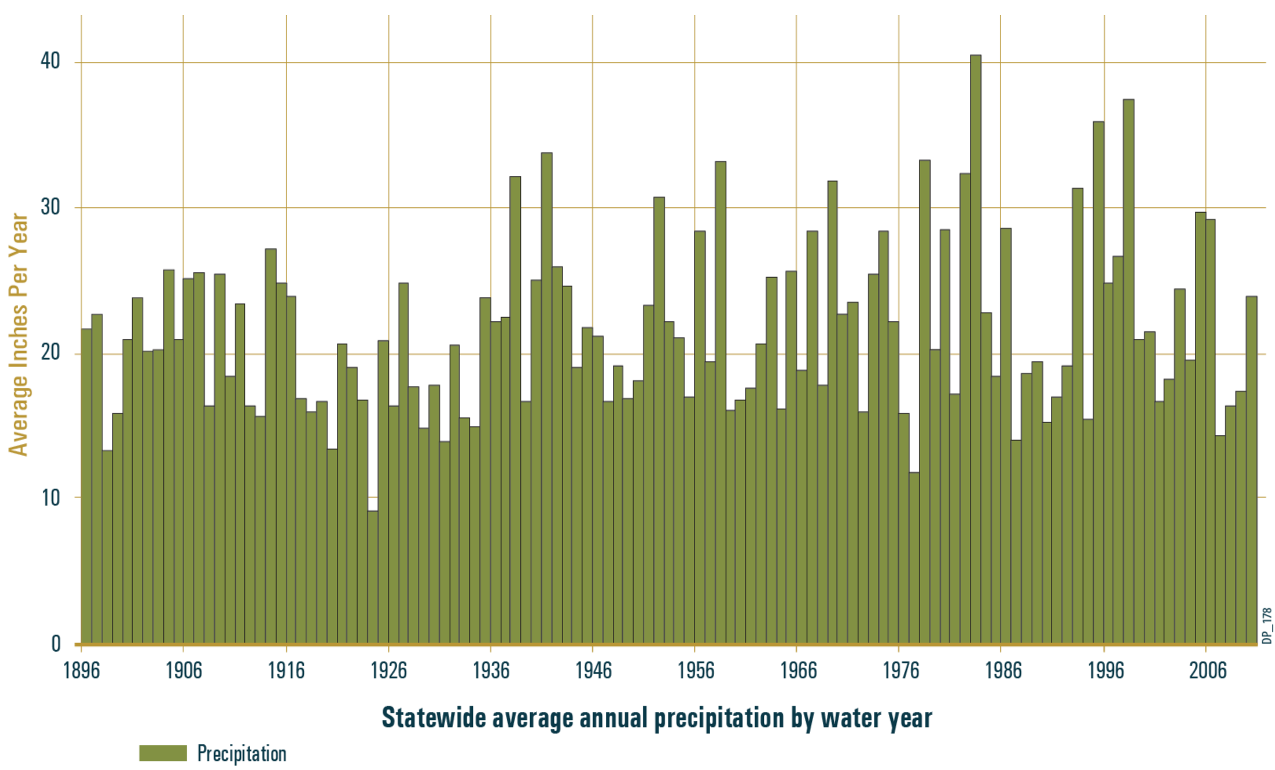


Figure 1-3 The unpredictability of the state's rainfall and its history of multiyear droughts make the management of water to reliably meet environmental and human uses extremely challenging. Yearly precipitation was calculated from the average of 95 stations located across California. Data were collected by Jim Goodridge, former State climatologist.

Source: Western Regional Climate Center 2011

Today, some two-thirds of the state's population (approximately 27 million people) depend on water from the Delta watershed for some portion of their water supply, as do more than 3 million acres of irrigated farmland that grow crops for in-state, national, and international distribution. That said, water exported through the Delta represents approximately 8 percent of the state's annual average water supply. Local and regional water resources, including surface diversions, groundwater, local and out-of-state imports, and water reuse, meet the remaining 84 percent.

Who uses all that water, how it is used, how much returns to the rivers and streams for downstream users, and in what quality, is less than certain on a statewide basis. Data for actual water use and water quality suffer from significant gaps, which may affect the ability of California's water managers to make timely and better-informed decisions. Since 1914, the State Water Resources Control Board (SWRCB) has issued permits to post-1914 appropriative-right water diverters in the Delta, but actual annual diversion amounts are not thoroughly measured or reported. Owners and operators of nearly one-third of irrigated lands in the Delta watershed do not participate in programs to meet water quality standards, and their compliance with State law is unclear.

Although groundwater and surface water are often interconnected, the SWRCB has limited authority to regulate groundwater. Groundwater is sustainably managed in some areas of the state through either adjudication or special districts, but other areas suffer from unsustainable overdraft and require improved management efforts. Attempts to correct this overdraft often put more pressure on water supplies from the Delta, demonstrating once again the interconnectedness of California's water systems.

The Delta and Its Ecosystem

Although much of the debate over the Delta has centered on events in the last 50 years, the roots of its problems run much deeper. A Delta that for millennia had been a land and waterscape of dynamic floodplain and tidal marshland, rich in flora and fauna, was changed forever by passage of the federal Swamp Land Act of 1850 and similar State legislation in 1861, which provided incentives for the "reclamation" of "nuisance" swampland to reduce threats of vector-borne disease and to gain productive land for farming. Within the Delta, seasonally and tidally flooded land impeding agricultural development led to land reclamation and channelization, and subsequent habitat loss. More than a century ago, with little or no engineering analyses and limited construction tools, Delta residents began to build an intricate levee system to channel water and dry out land, which converted hundreds of thousands of acres of seasonally and tidally flooded wetlands into fertile agricultural fields. As a result of continued land use change and urbanization, 95 percent of the historical tidal marsh in the Delta has been lost. Further detail regarding the historical Delta landscape is provided in Chapter 4.

Hydraulic gold mining, which reached its peak in the 1860s, sent tons of mercury-laden debris down toward the Delta, clogging channels and streams, and leading to devastating floods. Corrective actions—dredging and new levee construction—resulted in the loss of 90 percent of the Central Valley's riparian habitat (Katibah 1984). This massive-scale destruction has had lasting consequences for ecosystem health and, in turn, declining ecosystem health has had direct consequences for water supply operations.

The Hetch Hetchy and Mokelumne aqueducts diverted water (as they do currently) before it reached the Delta, and water use upstream increased considerably during the mid- and late 1900s. Construction of the CVP and SWP in the 1940s and 1960s, respectively, introduced new pressures on the Delta. Indeed, it is unusual to use an estuary—normally where fresh and salt water mix according to variable tidal and tributary flows—as a conveyance system for large amounts of fresh water to meet seasonal user demands.

The resulting configuration today causes river channels at times to run backward; and some fish, lacking clear migration corridors and/or migration cues, end up in dead-end channels or, worse yet, "salvaged" at the export pumps. Conflict between these competing uses was soon apparent and continues to plague water policy today.

Fish species have changed over time in response to changing habitat and flows, and from introductions both planned and accidental. Among the first introductions, in 1879, were two eastern game fish—striped bass and American shad. Today, striped bass, which are voracious predators, both support a major sport fishery and are blamed by some for the decline of smelt and salmon. Among the accidental tourists who came to stay are Asian clams, voracious eaters who can deplete the water of nutrients for native species. Of the more than 50 species of fish in the Delta today, more than half, including the most successful, are nonnative.

In addition, growing agricultural production in the Central Valley has resulted in increased runoff of pesticides and fertilizer flowing to the Delta. Runoff and wastewater discharges from increasing upstream urbanization have altered Delta water quality and, thus, its ecosystem. Increased commercial and recreational boat traffic in the Delta, as well as other causes, have introduced many nonnative species that have altered the Delta ecosystem.

The Delta as a Unique and Evolving Place

The Delta is a unique place distinguished by geography, legacy communities, a rural and agricultural setting, vibrant natural resources, and a mix of economic activities. Much has changed over the past 160 years; and although some may desire to maintain a static picture of the Delta as it is today, the past, as well as emerging science, predict constant change.

Once a marshland that was the drain of the vast Central Valley watershed, the Delta changed dramatically following the discovery of gold on the American River in 1848. Suddenly, large numbers of prospectors and service providers were beating a pathway through the Delta to the foothills and, at the peak of the rush, more than 300 steamboats plied the waters between San Francisco and Sacramento. Twenty-one years later, completion of the transcontinental railroad in 1869 freed a huge workforce, many of whom found alternative work dredging Delta channels and building levees.

Communities developed to support river traffic to and from the gold country, and later to transport agricultural products from the newly productive farmland reclaimed from the Delta marshes. The advent of the automobile resulted in a flurry of ferry construction and bridge building in the 1920s; by the 1930s, cars and trucks were replacing steamships for transportation and commercial shipping. The Stockton Deepwater Ship Channel was completed in 1933, opening a direct connection from the San Joaquin Valley to the world, and 30 years later, the Sacramento Deepwater Ship Channel did the same for the Sacramento Valley. Not coincidentally, these channels also opened the Delta to a host of exotic invasive species that hitched rides on the bottoms and in the ballast of oceangoing freighters.

Central Valley Chinook salmon have long been a critically important part of California's fishing industry, passing through the Delta on their way from and to spawning grounds in upstream rivers and streams. Between 1900 and 1950, the fall run numbered more than a million fish returning annually to the Sacramento and San Joaquin river systems. Drought and changing Delta and ocean conditions, however, reduced those numbers to only 66,000 in 2008, resulting in a closure of the salmon fisheries off California and restrictions that lingered into 2010, devastating fishing economies (DFG 2009).

Dredging opened many of the Delta channels for sport fishing, recreational boating, and commercial enterprise. Today there are more than 100 marinas and waterside resorts, RV parks, grocery stores, and dockside restaurants; and house boating remains popular. The Delta is dotted with numerous public parks and fishing sites as well.

The Delta now is a major producer of corn, alfalfa, pasture, and tomatoes; and wine grapes are growing in prominence. Residents and visitors alike celebrate the Delta's agricultural heritage with the Asparagus Festival in Stockton and the Courtland Pear Fair.

Today, although still largely rural, the Delta is crisscrossed by interstate electric transmission lines, natural gas pipelines, and interstate roads and railroads; and it faces increasing pressure—at least on its periphery—for additional housing development. Those elements, combined with the increasing certainty of sea level rise and changing climate patterns, mean continual change for the Delta.

The Delta Problem

In California, sustainable management of the Delta is an exceedingly complex topic fraught with longstanding conflicts and challenges. The Delta and Suisun Marsh ecosystem is the largest estuary on the West Coast and a critical stopping point on the Pacific flyway. The estuary extends westward to the Golden Gate and southward to San Jose. Delta water also flushes southern San Francisco Bay. It is also the hub of the state's major water supply systems. But the Delta today is failing to balance the tradeoffs inherent in these functions, as well as to provide a place to live, work, and play for residents and visitors alike.

Today the Delta is relied upon for many services and, as a result, is not meeting the demands of farmers and urban water users who want assurances of supply and, in some cases, more water. Nor does the Delta adequately serve the needs of fish and wildlife—some threatened or endangered species' numbers remain perilously low. And the Delta itself remains inherently floodprone.

Fish Declines. In late 2004, scientists noted that several fish species in the upper San Francisco estuary (delta smelt, young striped bass, longfin smelt, and threadfin shad) had remained unusually low since 2001. Although the numbers had historically fluctuated, this steep and lasting dropoff signaled an ecological crisis. Scientists acknowledged many causes such as invasive and predatory species, upstream agricultural and urban runoff, and diminished Delta habitat. The export pumps of the SWP and CVP were culpable as well, and restrictions ensued.

Water Exports Cut. These regulatory and court-ordered restrictions on State and federal pumping, in combination with the 2007–2009 drought, significantly reduced exported water deliveries to SWP and CVP contractors. As a result, some San Joaquin Valley farmers pumped groundwater from already overtapped aquifers, fallowed fields, and, in some cases, plowed under permanent crops. The national economic recession, combined with reduced water deliveries, hit the San Joaquin Valley hard. Although the plight of farmers captured much media attention, the salmon fishery was shut down in 2008 and was restricted in 2009–2010, causing economic hardship for the commercial and recreational fishing industries. Urban water managers in the Bay Area and Southern California drew down storage and increased conservation efforts until the rains and snows of 2011 saved the day.

DELTA BY THE NUMBERS

- The 45,600-square-mile Delta watershed provides all or a portion of surface water or groundwater supplies to more than 27 million California residents.
- Approximately 8 percent of the state's water supply is exported from the Delta (DWR 2009).
- The Delta and Suisun Marsh support more than 55 fish species and more than 750 plant and wildlife species. Of these, approximately 100 wildlife species, 140 plant species, and 13 taxonomic units of fish are considered special-status species and are afforded some form of legal or regulatory protection (CNDDB 2010, USFWS 2010, CNPS 2010).
- The Delta and Suisun Marsh are home to more than one-half million residents living in dozens of communities, including portions of 12 incorporated cities such as Stockton and Sacramento, and support more than 146,000 jobs (DPC 2010).
- Approximately 57 percent of the Delta and Suisun Marsh—more than 480,000 acres of agricultural land—currently supports a highly productive agricultural industry that is valued at hundreds of millions of dollars annually (DWR 2007a, DWR 2007b, DOC 2008, DPC 2010).
- The Delta and Suisun Marsh levees and lands support interstate and state highways and railroad tracks that support intrastate and interstate traffic, more than 500 miles of major electrical transmission lines, 60 substations, and more than 400 miles of major natural gas pipelines that provide energy throughout Northern California, as well as critical pipelines that carry transportation fuels to airports and other fuel depots throughout the San Francisco Bay Area and Sacramento (DPC 2010, DWR 2009).
- The Delta and Suisun Marsh have more than 1,335 miles of levees that protect more than 800,000 acres of land and play a role in the water supplies conveyed through the Delta.
- The Delta experiences more than 12 million visitor days annually from recreational boaters (DPC 2012).* Fishing, hunting, birdwatching, and camping draw even more visitors to the area.

* The *Sacramento–San Joaquin Delta Boating Needs Assessment* (2000-2020) estimated 6.4 million annual boating-related visitor days and 2.13 million boating trips to the Delta in 2000 (DBW 2002).

DP-318

Lawsuits. Over the years, improved understanding about water quality needs and environmental protection in the Delta launched an era of complex regulation that today governs SWP and CVP water supply operations. Litigation over a host of issues related to the CVP and SWP has created a recent spate of water management actions guided by courtroom decisions. Incomplete understanding about how water project operations, pollution, invasive species, and other factors affect native Delta fish species has resulted in a regulatory scheme affecting water supplies that is characterized by uncertainty. Changing rules to curtail pumping and increase Delta outflow have compounded water supply uncertainty for agencies that use water conveyed through the Delta, particularly in drier years when ecosystem conflicts are most pronounced. Some of those agencies have contributed to the uncertainty by becoming increasingly reliant on Delta exports that were intended to be supplemental supplies, but in some cases are now relied upon as core water supplies.

Flood Threats. Adding to the complexity of these problems is the increasing volatility of Delta water supplies as a consequence of climate change, including more rain and less snow, earlier snowmelt, and higher winter and lower spring-summer runoff patterns. The potential for catastrophic levee failure in the Delta and the risk to residents and infrastructure alike posed by floods, sea level rise, earthquakes, and land subsidence is real, growing, and has outpaced the State's ability to manage and fund risk-reduction measures.

Pursuit of Balance. Finding the right balance of these competing needs and demands on the Delta has bedeviled California policy makers for decades. The media and the political system tend to focus on water supply shortages, droughts, flood risk, and the decline of fisheries. Although notable and consequential, these events are all symptoms of a greater resource problem. Not unlike other policy areas, when it comes to natural resource issues, California has long attempted to manage symptoms rather than treat core problems.

Governance and the Delta Reform Act of 2009

California has a history of addressing each problem with yet another project and/or program, each generally left to find its own way among all others already set in motion or completed. Today, more than 200 federal, State, regional, and local agencies have responsibility for some aspect of the Delta. As each agency focuses on its specific mission, cooperation, collaboration, and cohesiveness have at times been elusive.

Although the seeds were sown in governmental decisions throughout the early twentieth century, California's water "wars" came to a head during the years 1987 through 1992, when a 6-year drought in California slowed water deliveries, water quality deteriorated, and two fish species unique to the Delta—the delta smelt and winter-run Chinook salmon—were pushed to the brink of extinction. During these 6 drought years, average runoff to the state's two largest rivers dipped dramatically: 44 percent into the Sacramento River and 53 percent into the San Joaquin.

State and federal officials tried, often in conflict with each other, to deal with issues of water quality, protection of Delta fisheries, and water impacts on the state's urban and agricultural water users. In the early 1990s, endangered species listings by federal fish agencies imposed export restrictions on water users. SWRCB efforts to address aquatic resource degradation under State water laws ground to a halt after the governor complained about excessive federal interference under both the Endangered Species Act and the Clean Water Act. In 1991, the U.S. Environmental Protection Agency (USEPA) formally disapproved the SWRCB water quality control plan; and in 1992, Congress passed the Central Valley Project Improvement Act (CVPIA), which reallocated a significant portion of federal (CVP) water supplies to environmental purposes. Virtually every action taken by a State or federal agency during this period ended up in court.

Amid this chaos of competing interests and regulations, the cornerstone for future cooperation was laid when three long-time adversarial interests—environmentalists, agriculture, and urban water users—agreed to work together to find common ground. Four federal agencies—the USEPA, Bureau of Reclamation, National Marine Fisheries Service, and U.S. Fish and Wildlife Service—began collaboration on Delta issues and became known as "Club Fed." After being on the losing side of a 5-year-long State-federal tug of war over water quality standards, the State and federal administrations negotiated updated water quality standards and, in 1995, created the CALFED Bay-Delta Program.

After 5 years of negotiations and planning, the CALFED agencies completed an ambitious 30-year plan and record of decision heavily dependent on goodwill, generous State and federal funding, and Delta conditions remaining generally as they had in the immediate past. Instead, goodwill and funding evaporated in the face of fiscal crisis, scientists learned more about looming effects of climate change and emerging stressors on the Delta, and competing interests turned back to the courts to force one viewpoint or the other.

While CALFED attempted to bring a holistic focus, it was criticized for not having authority to hold individual agencies and projects accountable for interrelationships and progress and—toward the end of its first 7 years (Stage 1, 2000 through 2008)—for not being focused enough on the Delta. And yet the inescapable truth remains: actions that affect the Delta's ecosystem and its ability to provide a reliable amount of water for export are inextricably linked. The Delta Vision Task Force, created by then-Governor Arnold Schwarzenegger in 2006 to point the path forward from CALFED, reinforced the need for integration and linkage in both its 2008 *Vision for the Delta* and its *Strategic Plan*.

IS MORE GOVERNANCE REFORM NEEDED?

Senate Bill X7 1 (SBX7 1), which included the Delta Reform Act, enacted the most significant governance reform related to water and the Delta since the mid-twentieth century. Two new bodies were formed, the Sacramento-San Joaquin Delta Conservancy and the Council; the Delta Protection Commission was reorganized; and a new Delta Watermaster position was created at the SWRCB. However, some argue that governance change should not stop there.

In recent years, two nonpartisan and independent entities have proposed new water and Delta governance models, with the State's Little Hoover Commission (LHC) releasing reports in 2005 and 2010, and the Public Policy Institute of California (PPIC) releasing reports in 2007 and 2011.* Their conclusions are summarized here.

Little Hoover Commission: LHC is an independent state oversight agency established in 1962. It has a mission to identify and spur government reform in various policy areas, and has confronted the topic of water governance multiple times. In August 2010, LHC proposed dramatic restructuring of Delta and water governance in its report *Managing for Change: Modernizing California's Water Governance* (www.lhc.ca.gov).

Public Policy Institute of California: Established in 1994, the mission of PPIC is to inform and improve public policy in California through independent, objective, nonpartisan research. In 2011, PPIC released *Managing California's Water: From Conflict to Resolution* (Hanak et al. 2011), which focused more on thematic reforms building on current practices such as increasing urban water conservation and streamlining water transfers (www.ppic.org).

Although PPIC and LHC would remake water governance differently, both proposals have considerable thematic overlap:

- California lacks a system to adequately incorporate the needs of public trust resources with water supply management and planning.
- California lacks a centralized leadership structure to set statewide policy goals and manage inevitable conflicts.
- The institutional separation of water rights planning, administration, and enforcement responsibilities from water supply management complicates policy making.
- Insufficient incentives exist to promote regional cooperation and local consistency with State policy directions.
- There is concern that the demands of California Department of Water Resources' role in managing the SWP conflicts with its overall statewide water planning responsibilities.

This Delta Plan recommends governance reform related to regional Delta participation in flood management activities. As part of its role in coordinating overall efforts in the Delta, the Council will hold hearings and recommend additional governance reform to the Legislature.

** LHC 2005, LHC 2010, Lund et al. 2007, Hanak et al. 2011*

DP-180

The recommendations from the Delta Vision Task Force, along with general understanding and support from a wide variety of competing interest groups, allowed the Legislature, in 2009, to craft a package of bills that would, for the first time, begin to define those linkages in law and require accountability for implementation. In addition to the Delta Reform Act, the package included measures that set ambitious water conservation policy (20 percent reduction in statewide urban per capita water use by 2020), ensure better groundwater monitoring, and provide for increased enforcement to prevent illegal water diversions. It also included a bond measure that would help fund implementation of various parts of the package, and local and regional water supply and ecosystem projects.

The fifth bill in the package was Senate Bill X7 1 (SBX7 1), which included the Delta Reform Act. With its passage, California embarked upon a new era in Delta governance with creation of the Council, and established as overarching State policy coequal goals of a more reliable water supply for California and protecting, restoring, and enhancing the Delta ecosystem. Through its hybrid approach—both regulatory and collaborative—the Council now has the task of facilitating coordination across a broad range of entities to achieve the State's water policy objectives.

The Delta Reform Act includes an important caveat: while past Delta efforts focused almost exclusively on water supply reliability or ecosystem protection, the Delta Reform Act requires that the coequal goals be achieved in a manner that protects and enhances the unique cultural, recreational, natural resource, and agricultural values of the Delta as an evolving place.

In addition, the Delta Reform Act recognized the need to change the way the Delta is viewed, asking not what can be taken, but instead what can be given back. Thus, the Legislature established that the policy of the State is to reduce reliance on the Delta in meeting future water supply needs through a statewide strategy of investing in improved regional supplies, conservation, and water use efficiency. The Delta Reform Act specifies that each region depending on water from the Delta watershed shall improve its regional self-reliance for water through investment in water use efficiency, water recycling, advanced water technologies, local and regional water supply projects, and improved regional coordination of local and regional water supply efforts.

Finally, in a distinct departure from CALFED and the status quo of disparate agencies struggling to tackle complex modern resource problems, the Council was established with the authority and responsibility to develop a legally enforceable Delta Plan, and to coordinate and collaborate across the myriad governmental agencies that have responsibility for some aspect of the Delta. The Council also was charged with ensuring that actions by State and local agencies in the Delta are consistent with the Delta Plan, and adequately incorporate the best available science and adaptive management principles.

The Delta Plan

The foundation of the Delta Reform Act is the adoption of the coequal goals and direction to the Council to develop an enforceable Delta Plan to further those goals. Figure 1-4 shows the primary area covered by the Delta Plan, including features and uses referred to in policies and recommendations. Accordingly, the Council presents a Delta Plan that is practical, foundational, integrated, and adaptive:

- **Practical:** The Delta Plan builds on years of planning efforts and incorporates actions, recommendations, and strategies developed by other entities—governmental and nongovernmental—that have already invested countless hours on Delta issues and have specialized expertise.
- **Foundational:** The Delta Plan addresses intertwined challenges and establishes foundational actions for Delta management throughout this century. It lays the groundwork for near-term actions for improvement and focuses on the immediate avoidance of further harm or increased risk to the Delta. The Delta Plan shines a spotlight on urgently needed Delta habitat projects and the significant potential for local and regional water supply development. Similarly, the Delta Plan seeks to immediately halt practices known to be detrimental to the sustainability of the Delta's many functions and services.
- **Integrated:** The Delta Plan establishes an open and accountable governance mechanism for coordinating actions across agency jurisdictions and statutory objectives.

The Delta Plan

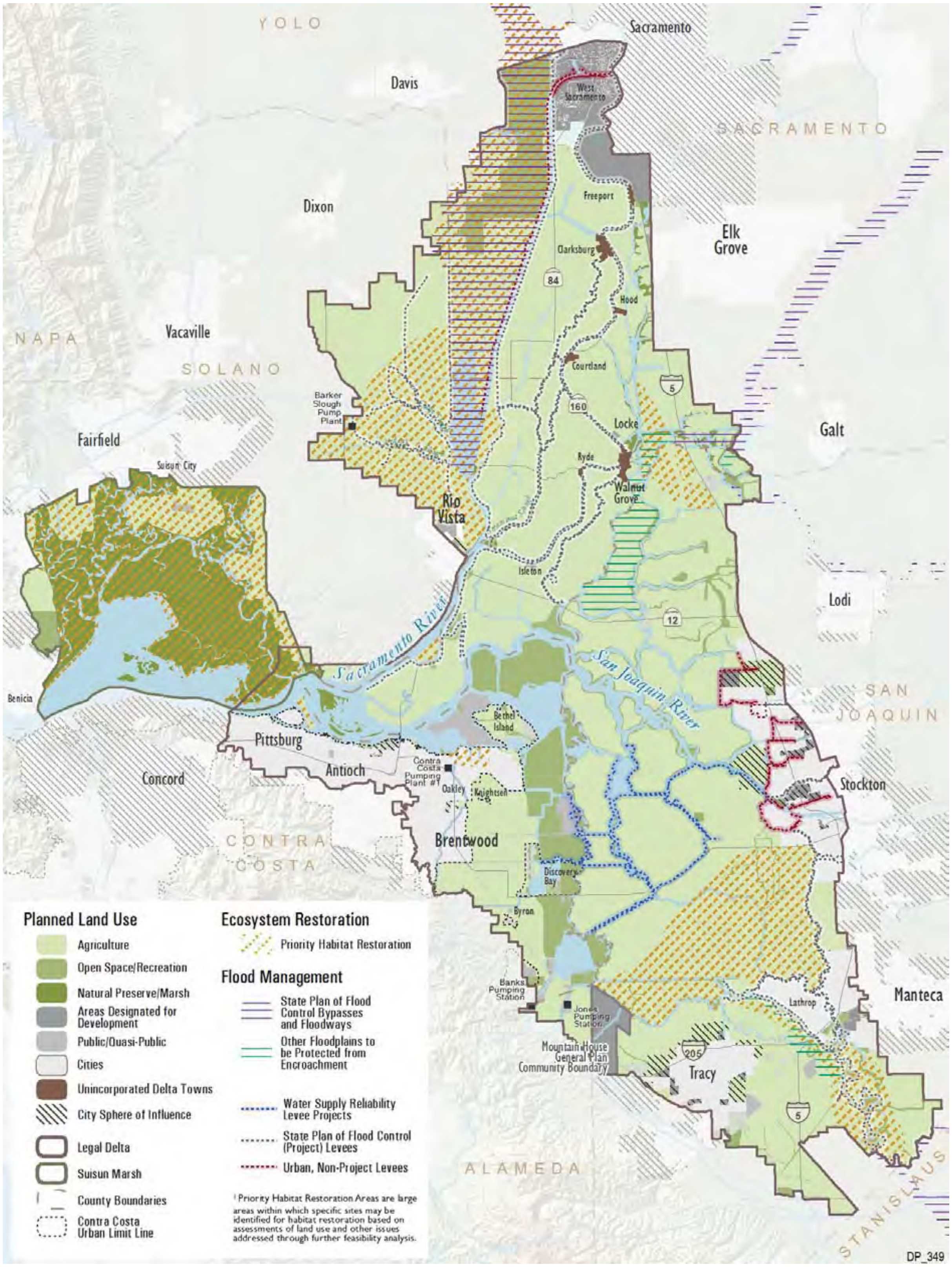


Figure 1-4 The map shows land uses designated by city and county general plans. Within cities' spheres of influences (SOIs), the map shows land use designations proposed in city general plans, where available. In cases where cities have not proposed land uses within their SOIs, the map shows land uses designated by county general plans.

Sources: City of Benicia 2003, Contra Costa County 2008, Contra Costa County 2010, DWR 2011b, DWR 2011c, DWR 2011d, City of Fairfield 2008, Jones & Stokes 2007, City of Lathrop 2012, City of Manteca 2012, Mountain House Community Services District 2008, City of Rio Vista 2001, SACOG 2009, City of Sacramento 2008, Sacramento County 2011, Sacramento County 2013, Sacramento County 2013, San Joaquin County 2008a, San Joaquin County 2008b, Solano County 2008a, Solano County 2008b, South Delta Levee Protection and Channel Maintenance Authority 2011, City of Stockton 2011a, City of Stockton 2011b, City of Suisun City 2011, City of Tracy 2011, City of Stockton 2011b, City of West Sacramento 2010, Yolo County 2010a, Yolo County 2010b.

- **Adaptable:** The Delta Plan sets direction through policies and recommendations and can incorporate other plans and new information as it becomes available. Informed by science and consistent monitoring, portions of the Delta Plan that do not adequately meet or make progress toward stated goals over time will be refined or revised. The Delta Plan will be updated at least every 5 years, and likely sooner, given the major changes facing the Delta under the Bay Delta Conservation Plan (BDCP) and the Council's commitment to Delta levee prioritization.

It is inevitable that the Delta Plan will generate controversy. This Delta Plan integrates existing State and federal laws and policies and ongoing programs, and is informed by the best available science to chart a course to further the coequal goals. The Council is one of many agencies with an interest in the Delta, and it was not granted unlimited authority over actions related to water supply and the environment. Specific and targeted authority and actions, however, were included by the Delta Reform Act; these form the basis for the Delta Plan's enforceable policies and nonenforceable recommendations.

The Delta Plan's policies and recommendations are based on the following imperatives:

- **Act now.** We have been studying the problems of California's water supply and the declining Delta ecosystem for decades. While all parties agree the *status quo* is not acceptable, failure to take action only prolongs a worsening *status quo*. Near-term actions must move forward while the long-term conveyance, storage, and ecosystem solutions are being decided over the next 5, 10, and 15 years. Waiting is NOT an option. We must continue to invest in the Delta ecosystem and in the improvement of California's water supplies and water use efficiency.
- **Success depends on integrated approaches and awareness of tradeoffs.** Tradeoffs are inherent in managing a supply for multiple benefits. Water exports out of the Delta can harm the ecosystem unless carefully managed. Protecting the Delta as a place means focusing development in urban areas to reduce effects on agricultural land, and risk to people, property, and state interests. Multiple stressors affect the ecosystem in ways that are not yet fully understood and which may be impossible to completely control. The most effective actions will depend upon the coordinated actions of multiple actors.
- **Improve water supply reliability.** Fundamentally, water supply reliability means that California must better match its demands for and use of water to the available supply. Everyone in California must conserve water and must increase their efforts to do so. New surface and groundwater storage is necessary to manage the timing of water for people and for fish. Done right, additional storage can make efficient water management possible and better allow for water use that is wildlife friendly. Improved Delta conveyance, including successful completion of the BDCP, is essential; and it should be done as soon as possible.
- **Commit to Delta ecosystem restoration.** We must preserve land in the Delta for future habitat restoration, and we must immediately begin restoration efforts on long-studied priority areas. In the Delta, the conflict between the way we move water and the health of native species must be resolved. A successfully permitted BDCP is key to that, including water quality objectives updated by the SWRCB for beneficial uses including the Delta's ecosystem. Without adequate water flow (the right mix of timing and amount), we cannot expect fisheries to recover, no matter how well we deal with the range of other stressors.
- **Preserve Delta as a place.** The Delta serves many demands, but we must preserve and protect a unique sense of place distinguished by geography, legacy communities, a rural and agricultural setting, vibrant natural resources, and a mix of economic and recreational activities.

What the Delta Plan Will Achieve

The Delta Plan seeks to further the coequal goals and their inherent objectives in the face of dramatically changing conditions. The Delta of 2100 likely will be very different from the Delta of today (see Table 1-1 for examples of anticipated changes). Some of the changes will be intentional or predictable, and others will be unintended and surprising. Changes are likely or expected to result from population growth, climate change and sea level rise, land subsidence, and earthquakes—most beyond human ability or willingness to control. Human-made changes in land use and water use are also expected to continue.

All of this will involve tradeoffs between competing—in some cases, mutually exclusive—values, goals, and objectives. The Delta Plan seeks to ensure that these decisions are made in a timely and open manner, and based on best available information and science as a predictor of the future. The law requires that the Delta Plan be updated every 5 years, and each update is intended to build on an evolving base of knowledge, directing near- and mid-term actions, and preserving and protecting longer-term opportunities as yet unknown.

Summary of Anticipated Changes Affecting the Delta by 2050 and 2100

TABLE 1-1

Anticipated Change	Change Predicted by 2050	Change Predicted by 2100
Population of California[a]	Increase from 37.2 million in 2010 to 51 million	Continued increase in population
San Francisco Bay/East Bay Area earthquake affecting Delta by 2032[b]	63% probability of at least one magnitude 6.7 or greater earthquake	
Probability of island flooding from high water, relative to 2005 conditions[c]	In range of 200% increase (medium risk scenario)	In range of 450% increase (medium risk scenario)
Increased weather variability, including longer-term droughts[d]	Models and analyses of tree rings and other evidence back to the year 800 suggest greater variability and long periods of drought, especially for the Colorado River Basin, a current source of some water to California.	
Sea level rise, relative to 2000[e]	14 inches	55 to 65 inches
Snow pack, relative to 1956–2000 average of 15 MAF[f]	Reduction of 25% (4.5 MAF) to 40% (6 MAF)	Continued reduction expected

a California Department of Finance 2012

b 2007 Working Group on California Earthquake Probabilities 2008

c DWR 2008

d For examples, see research by Richard Seager, Columbia University, available at http://www.ldeo.columbia.edu/res/div/ocp/drought/, or the California Global Climate Change Portal, available at http://www.climatechange.ca.gov

e California Ocean Protection Council 2011; other sources include higher projections

f DWR 2010

MAF: million acre-feet

The Delta Plan lays out 14 regulatory policies and 73 recommendations that start the process of addressing the current and predicted ecological, flood management, water quality, and water supply reliability challenges. As required by statute, the Delta Plan adopts a science-based adaptive management strategy to manage decision making in the face of uncertainty (Water Code section 85308(f)). All of these changes—some foreseeable, some not—will create a dynamic context in which the Delta Plan must adapt.

Over the life of the Delta Plan, the coequal goals of providing a more reliable water supply for California and restoring the Delta ecosystem are the foundation of all State water management policies. No water rights decisions or water contracts that directly or indirectly impact the Delta are made without consideration of the coequal goals. Over time, balanced application of the Public Trust Doctrine and the California Constitution, Article 10, Section 2 (requirements for beneficial use, reasonable water use, and no waste), have produced optimized water use, including high levels of water use efficiency and protection of public trust resources throughout the state. California has a comprehensive, fully integrated system for tracking and evaluating actual water use and water quality for both surface water and groundwater supplies.

The Delta Plan seeks first to arrest declining water reliability and environmental conditions related to the Delta ecosystem, and ultimately to improve them. It seeks to achieve a more resilient ecosystem that can absorb and adapt to current and future effects of multiple stressors. Additionally, it seeks to reduce flood risk, improve water quality, increase recreation opportunities in the Delta, and protect Delta legacy communities. Generally speaking, these are long-term goals to reduce and reverse increasing long-term environmental impacts caused by inaction. The vision of the Delta in 2100 will be realized through a series of near-term and longer-term actions informed by performance measures and overall adaptive management.

By 2100:

- **California's water supply** will be considerably more efficient, local and regional projects will be online to increase supplies and meet the demands of a growing population, and storage will have increased to meet the challenge of climate change and the needs of water transfer systems. Regions reliant on receiving some portion of their water from the Delta watershed will have reduced their reliance and improved regional self-reliance through increased conservation and diversification of their local and regional sources of supply. Delta conveyance will be managed in an adaptive manner that successfully balances ecosystem restoration and protection with more reliable water deliveries. Water quality in the Delta will support a healthy ecosystem and the multiple beneficial uses of water, including municipal supply and recreational uses such as fishing and swimming.
- **The Delta and Suisun Marsh ecosystem** will have the capacity to provide the environmental and societal benefits the public demands (viable populations of desired species, wild habitats for recreation and solace, land for agriculture, and the conveyance of reliable and high-quality fresh water). Large areas of the Delta will be restored in support of a healthy estuary. A diverse mosaic of interconnected habitats will be re-established in the Delta and its watershed. Migratory corridors for fish, birds, and terrestrial wildlife will be largely protected and restored. Actions have been taken to ensure that sufficient freshwater flows following a more natural, functional hydrograph are now dedicated to support a healthy ecosystem. Actions have reduced the impacts caused by stressors such as invasive species, poor water quality, loss of habitat, and urban development, resulting in improved conditions for native species of fish, birds, and wildlife that depend on the Delta and its watershed.

- **The Delta itself** will be a safe, nationally recognized and vibrant place, with well-defined cities and towns, a strong agricultural sector, and a well-deserved reputation as a recreational destination. Despite an increase in sea levels and altered runoff patterns, risks will be reduced, and residents and agencies will be prepared to respond when floods threaten. In 2100, the Delta will retain its rural heritage and be a place where agricultural, recreational, and environmental uses are uniquely integrated and continue to contribute in important ways to the regional economy.

Timeline for Implementing Priority Actions of the Delta Plan

Figure 1-5 contains a timeline for implementing the priority actions contained in the Delta Plan. The timeline emphasizes near-term and intermediate-term actions. In some instances, precedent or complementary actions need to be undertaken by other agencies or entities to ensure success of the Delta Plan.

Priority Action Timeline

TIMELINE **CHAPTER 1: Priority Actions**

	ACTION (REFERENCE #)	LEAD AGENCY(IES)	NEAR TERM 2012–2017	INTERMEDIATE TERM 2017–2025	ACTION DEPENDS ON
POLICIES	**Reduce reliance on the Delta through improved regional water self-reliance** (WR P1)	Council, DWR, SWRCB	●	●	State, local water agency cooperation and compliance
POLICIES	**Delta flow objectives** (ER P1)	SWRCB	●	●	SWRCB completes on time
POLICIES	**Prioritization of State investments in Delta levees and risk reduction** (RR P1)	Council, DWR	●	●	Council completion; legislative adoption and implementation
RECOMMENDATIONS	**Update Delta flow objectives** (ER R1)	SWRCB	●	●	SWRCB completes on time
RECOMMENDATIONS	**Prioritize and implement projects that restore Delta habitat** (ER R2)	DFW, DWR, Delta Conservancy	●	●	Funding, multiagency cooperation
RECOMMENDATIONS	**Designate the Delta as a National Heritage Area** (DP R1)	DPC	●		Federal action, Congress
RECOMMENDATIONS	**Finance local flood management activities** (RR R2)	DPC	●	●	
RECOMMENDATIONS	**Actions for the prioritization of State investments in Delta levees** (RR R4)	Council, DWR	●		Council completion; legislative adoption and implementation
RECOMMENDATIONS	**Complete Bay Delta Conservation Plan** (WR R12)	DWR, Council incorporates	●	●	State, federal agency action
RECOMMENDATIONS	**Complete surface water storage studies** (WR R13)	DWR	●	●	
RECOMMENDATIONS	**Completion of regulatory processes, research, and monitoring for water quality improvements** (WQ R8)	SWRCB, RWQCBs	●		
RECOMMENDATIONS	**Development of a Delta Science Plan** (G R1)	Council	●	●	
OTHER	Complete Delta Finance Plan	Council	●		Ongoing funding
OTHER	Initiate Delta Plan Interagency Implementation Committee	Council	●	●	Agency cooperation
OTHER	Evaluate and update Delta Plan	Council	●		Ongoing funding

DP_340

Agency Key:
Council: Delta Stewardship Council
Delta Conservancy: Sacramento-San Joaquin Delta Conservancy
DFW: California Department of Fish and Wildlife
DPC: Delta Protection Commission
DWR: California Department of Water Resources
RWQCB: Regional Water Quality Control Board
SWRCB: State Water Resources Control Board

Figure 1-5

Organization of the Delta Plan

The Delta Plan is organized around the coequal goals and specific subgoals, strategies, actions, and measures set forth in the Delta Reform Act. The following chapters describe in detail the problems, expected outcomes, and performance measures associated with the various policies and recommendations:

- Chapter 2, The Delta Plan
- Chapter 3, A More Reliable Water Supply for California
- Chapter 4, Protect, Restore, and Enhance the Delta Ecosystem
- Chapter 5, Protect and Enhance the Unique Cultural, Recreational, Natural Resource, and Agricultural Values of the California Delta as an Evolving Place
- Chapter 6, Improve Water Quality to Protect Human Health and the Environment
- Chapter 7, Reduce Risk to People, Property, and State Interests in the Delta

In addition, Chapter 8, Funding Principles to Support the Coequal Goals, provides history and background for water project and program financing by discussing various funding schemes and by providing some current data on water-related expenditures in California. It also outlines guiding principles for developing stable financing for Delta Plan implementation and describes urgently needed near-term funding requirements for certain critical activities.

References

2007 Working Group on California Earthquake Probabilities. 2008. The Uniform California Earthquake Rupture Forecast, Version 2 (UCERF 2). U.S. Geological Survey Open-File Report 2007-1437 and California Geological Survey Special Report 203. http://pubs.usgs.gov/of/2007/1437/of2007-1437_text.pdf, or Presentation to Delta Stewardship Council: http://www.deltacouncil.ca.gov/ delta_council_meetings/january_2011/Item_15_Presentation.pdf.

California Department of Finance. 2012. Interim Population Projections for California and its Counties 2010-2050, Sacramento, California. May. http://www.dof.ca.gov/research/demographic/reports/projections/interim/view.php.

California Ocean Protection Council. 2011. *Resolution of the California Ocean Protection Council on Sea-Level Rise*. March. http://www.opc.ca.gov/webmaster/ftp/pdf/docs/ OPC_SeaLevelRise_Resolution_Adopted031111.pdf.

City of Benicia. 2003. General Plan land use designations within Suisun Marsh. Digitized into GIS format by AECOM from City of Benicia Land Use map in 2012.

City of Fairfield. 2008. General Plan land use designations within Suisun Marsh. Received from the City of Fairfield in 2012.

City of Lathrop. 2012. General Plan Land Use map for the City of Lathrop. October. Site accessed March 14, 2013. http://www.ci.lathrop.ca.us/cdd/documents/.

City of Manteca. 2012. General Plan land use designations in GIS format. Received by Eryn Pimentel, AECOM, from Jeffrey Davis, City of Manteca, on September 4.

City of Rio Vista. 2001. General Plan land use designations in electronic non-GIS format. Site accessed 2009. http://www.riovistacity.com/images/Documents/chapter_04.pdf.

City of Sacramento. 2008. General Plan land use designations in electronic GIS format. Site accessed 2009. http://www.cityofsacramento.org/gis/data.html.

City of Stockton. 2011a. GIS layers for city spheres of influence and General Plan land use designations. Site accessed April 14, 2011. http://www.stocktongov.com/services/gis/mapdatDat.html.

City of Stockton. 2011b. General Plan land use designations in GIS format and General Plan land use designations within Suisun Marsh (digitized into GIS format by AECOM from Land Use map in 2012). Site accessed April 14, 2011. http://www.stocktongov.com/services/gis/mapdatDat.html.

City of Suisun City. 2011. General Plan land use designations within Suisun Marsh. Digitized into GIS format by AECOM from Land Use map in 2012.

City of Tracy. 2011. City of Tracy sphere of influence and General Plan land use designations provided in GIS format. Delivered via file transfer protocol from Victoria Lombardo, Senior Planner, City of Tracy, to Jessica Law, Urban and Environmental Planner, AECOM, on March 10.

City of West Sacramento. 2010. General Plan land use designations in GIS format. Site accessed December 28, 2010. http://www.cityofwestsacramento.org/services/gis/downloads.cfm. Accessed

CNDDB (California Natural Diversity Database). 2010. Records search of plan area quadrangles. California Department of Fish and Game, Sacramento, California.

CNPS (California Native Plant Society). 2010. Inventory of Rare and Endangered Plants. Site accessed February 2010. http://cnps.web.aplus.net/cgi-bin/inv/inventory.cgi.

Contra Costa County. 2008. GIS layer for Urban Limit Line for Contra Costa County. October. Site accessed June 27, 2011. http://ccmap.us/Details/asp?Product=134490.

Contra Costa County. 2010. GIS layer for City Spheres of Influence in Contra Costa County. January. Site accessed January 28, 2011. https://www.ccmap.us/catalog.asp?UserChoice=2&Layercntrl=0000000000000000000000.

DBW (California Department of Boating and Waterways). 2002. *Sacramento–San Joaquin Delta Boating Needs Assessment (2000-2020)*. Prepared by The Dangermond Group.

DFG (California Department of Fish and Game). 2009. *Outdoor California*. (page 8). July-August.

DOC (California Department of Conservation). 2008. Farmland Mapping and Monitoring Program 2008. Important Farmland designations for Alameda, Contra Costa, Sacramento, San Joaquin, Solano, and Yolo Counties. ftp://ftp.consrv.ca.gov/pub/dlrp/fmmp/.

DPC (Delta Protection Commission). 2010. *Economic Sustainability Plan Framework Study*. Final Draft. Submitted by Bay Area Economics in association with Rooney Tate Group Parus Consulting. December 6.

DPC (Delta Protection Commission). 2012. Proposal to Protect, Enhance, and Sustain the Unique Cultural, Historical, Recreational, Agricultural, and Economic Values of the Sacramento-San Joaquin Delta as an Evolving Place. January 26.

DWR (California Department of Water Resources). 2007a. *Past and Present Land Uses in the Sacramento-San Joaquin Delta and Suisun Marsh*. Water Plan Land and Water Use Work Team. November 21.

DWR (California Department of Water Resources). 2007b. Land use survey agricultural crop data for the Legal Delta and Suisun Marsh area. Developed for the Delta Vision program. Received by AECOM from DWR.

DWR (California Department of Water Resources). 2008. *Delta Risk Management Strategy. Risk Analysis Report Final.* Tables 14-12 and 14-13. Raising levees to keep up with sea level rise is assumed (page 14-28). December. http://www.water.ca.gov/floodmgmt/dsmo/sab/drmsp/ docs/Risk_Report_Section_0_Final.pdf. See also: http://www.science.calwater.ca.gov/pdf/ drms/IRP_DRMS_Review_Final_20oct08.pdf and CALFED Independent Science Board assessment of DWR Delta Risk Management Strategy Phase 1, page 22: http://www.science.calwater.ca.gov/pdf/drms/Appendix_5_executive_summary_review.pdf.

DWR (California Department of Water Resources). 2009. *California Water Plan Update 2009*. Sacramento, CA. http://www.waterplan.water.ca.gov/cwpu2009/index.cfm.

DWR (California Department of Water Resources). 2010. *Climate Change Characterization and Analysis in California Water Resources Planning Studies.* Final Report. December.

DWR (California Department of Water Resources). 2011a. Dayflow. Estimate of Average Daily Outflow. Site accessed August 2011. http://www.water.ca.gov/dayflow/.

DWR (California Department of Water Resources). 2011b. Floodplain inundation and floodways in the vicinity of the Sacramento-San Joaquin Delta.

DWR (California Department of Water Resources). 2011c. Locations and attributes of levees in California as maintained by the DWR California Levee Database.

DWR (California Department of Water Resources). 2011d. Restoration opportunity areas in the Sacramento-San Joaquin Delta.

Hanak, E., J. Lund, A. Dinar, B. Gray, R. Howitt, J. Mount, P. Moyle, and B. Thompson. 2011. *Managing California's Water: From Conflict to Reconciliation*. San Francisco, CA. Public Policy Institute of California.

Hart, John. 2010. The once and future Delta. *Bay Nature*. April 1, 2010. http://baynature.org/articles/apr-jun-2010/the-once-and-future-delta/once-future-delta.

Jones & Stokes. 2007. *Draft Environmental Impact Report North Delta Flood Control and Ecosystem Restoration Project*. Volume 2-Figures. November.

Katibah, E. F. 1984. A brief history of riparian forests in the Central Valley of California. In *California Riparian Systems: Ecology, Conservation, and Productive Management*. R. E. Warner and K. M. Hendrix, eds. (pages 23–29). University of California Press, Berkeley.

LHC (Little Hoover Commission). 2005. Still Imperiled, Still Important. The Little Hoover Commission's Review of the CALFED Bay-Delta Program. November 17.

LHC (Little Hoover Commission). 2010. *Managing for Change: Modernizing California's Water Governance*. Report 201. August.

Lund, J., E. Hanak, W. Fleenor, R. Howitt, J. Mount, P. Moyle. 2007. *Envisioning Futures for the Sacramento-San Joaquin Delta*. Public Policy Institute of California. San Francisco, CA.

Mountain House Community Services District. 2008. Mountain House Zoning map. September 18, 2008. Site accessed July 27, 2011. http://www.ci.mountainhouse.ca.us/master-plan.asp.

SACOG (Sacramento Area Council of Governments). 2009. GIS layer for spheres of influence in SACOG region. December. Site accessed January 28, 2011. http://sacog.org/mapping/clearinghouse/Mapping Center.

Sacramento County. 2011. General Plan land use designations in GIS format. Site accessed 2012. http://www.sacgis.org/GISDataPub/Data/.

Sacramento County. 2012. Letter from Sacramento County to the Delta Stewardship Council, Re: Revised Maps of the Unincorporated Delta Communities. November 20.

Sacramento County. 2013. Sacramento County Online Map, Sacramento County, California. Site accessed March 10, 2013. http://generalmap.gis.saccounty.net/JSViewer/county_portal.aspx.

San Joaquin County. 2008a. City of Lathrop sphere of influence map. March 4. Site accessed February 3, 2011. http://www.sjgov.org/lafco/SOI%20Maps/Lathrop_Sphere_new%202008.pdf.

San Joaquin County. 2008b. City of Manteca sphere of influence map. October 29. Site accessed February 3, 2011. http://www.co.san-joaquin.ca.us/lafco/Manteca%20MSR/Manteca_Sphere.pdf.

Solano County. 2008a. GIS layers for city spheres of influence and General Plan land use designations in Solano County. May. Site accessed August 10, 2011. http://regis.solanocounty.com/data.html.

Solano County. 2008b. General Plan land use designations provided in GIS format. Obtained 2009.

South Delta Levee Protection and Channel Maintenance Authority. 2011. *Lower San Joaquin Flood Bypass Proposal*. March.

USFWS (U.S. Fish and Wildlife Service). 2010. Records search of Federal Endangered and Threatened Species in plan area quadrangles. Site accessed February 16, 2010. http://www.fws.gov/ sacramento/es/spp_lists/auto_list.cfm.

Western Regional Climate Center. 2011. California climate tracker database query. Statewide annual precipitation by water year from 1896-2010. Site accessed July 2011. http://www.wrcc.dri.edu/monitor/cal-mon/frames_version_html.

Yolo County. 2010a. General Plan land use designations in GIS format. Site accessed 2010. http://www.yolocounty.org/Index.aspx?page=823.

Yolo County. 2010b. Yolo County General Plan 2030 layer provided in GIS format. Delivered via file transfer protocol from Marcus Neuvert, GIS Specialist, Yolo County DITT, to Dillon Cowan, Staff Engineer, CH2M HILL, Inc., on July 1.

Photo Credits

Chapter Divider *(clockwise from top left)***:** Delta Conservancy, Delta Conservancy, Chris Austin, Bill Wells

Page 8: California Department of Water Resources

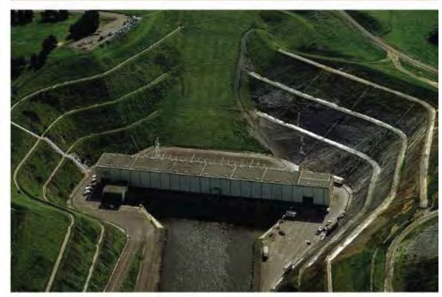
Page 14: Delta Conservancy

This page intentionally left blank

CHAPTER 2

The Delta Plan






ABOUT THIS CHAPTER

This chapter discusses the purpose and role of the Delta Stewardship Council (Council) in the context of Sacramento-San Joaquin Delta (Delta) governance. It also describes the Council's approach to developing, implementing, and updating the Delta Plan, all within the framework of adaptive management. It describes why best available science and adaptive management are particularly important tools in the Delta, and proposes the development of a new Delta Science Plan to aid in the coordination and focus of science efforts across agencies. For State of California (State) or local agencies that propose a plan, program, or project occurring in whole or in part in the Delta, this chapter contains a description of the regulatory application of the Delta Plan. For instance:

- What is a covered action?
- Certifications of consistency
- Covered action consistency appeals

The chapter includes one policy and one recommendation.

RELEVANT LEGISLATION

The Sacramento-San Joaquin Delta Reform Act of 2009 established the Delta Stewardship Council to achieve more effective governance while providing for the sustainable management of the Delta ecosystem and a more reliable water supply, using an adaptive management framework, as reflected in the Water Code sections below.

85001 (c) By enacting this division, it is the intent of the Legislature to provide for the sustainable management of the Sacramento-San Joaquin Delta ecosystem, to provide for a more reliable water supply for the state, to protect and enhance the quality of water supply from the Delta, and to establish a governance structure that will direct efforts across state agencies to develop a legally enforceable Delta Plan.

85020 (h) Establish a new governance structure with the authority, responsibility, accountability, scientific support, and adequate and secure funding to achieve these objectives.

85022 (a) It is the intent of the Legislature that state and local land use actions identified as "covered actions" pursuant to Section 85057.5 be consistent with the Delta Plan. This section's findings, policies, and goals apply to Delta land use planning and development.

85052 "Adaptive management" means a framework and flexible decision making process for ongoing knowledge acquisition, monitoring, and evaluation leading to continuous improvement in management planning and implementation of a project to achieve specified objectives.

85204 The council shall establish and oversee a committee of agencies responsible for implementing the Delta Plan. Each agency shall coordinate its actions pursuant to the Delta Plan with the council and the other relevant agencies.

85211 The Delta Plan shall include performance measurements that will enable the council to track progress in meeting the objectives of the Delta Plan. The performance measurements shall include, but need not be limited to, quantitative or otherwise measurable assessments of the status and trends in all of the following:

(a) The health of the Delta's estuary and wetland ecosystem for supporting viable populations of aquatic and terrestrial species, habitats, and processes, including viable populations of Delta fisheries and other aquatic organisms.

(b) The reliability of California water supply imported from the Sacramento River or the San Joaquin River watershed.

85225.5 To assist state and local public agencies in preparing the required certification, the council shall develop procedures for early consultation with the council on the proposed covered action.

85225.10 (a) Any person who claims that a proposed covered action is inconsistent with the Delta Plan and, as a result of that inconsistency, the action will have a significant adverse impact on the achievement of one or both of the coequal goals or implementation of government-sponsored flood control programs to reduce risks to people and property in the Delta, may file an appeal with regard to a certification of consistency submitted to the council.

(b) The appeal shall clearly and specifically set forth the basis for the claim, including specific factual allegations, that the covered action is inconsistent with the Delta Plan. The council may request from the appellant additional information necessary to clarify, amplify, correct, or otherwise supplement the information submitted with the appeal, within a reasonable period.

(c) The council, or by delegation the executive officer, may dismiss the appeal for failure of the appellant to provide information requested by the council within the period provided, if the information requested is in the possession or under the control of the appellant.

85300(c) The council shall review the Delta Plan at least once every five years and may revise it as the council deems appropriate. The council may request any state agency with responsibilities in the Delta to make *recommendations with respect to revision of the Delta Plan.*

(d) (1) The council shall develop the Delta Plan consistent with all of the following:

(A) The federal Coastal Zone Management Act of 1972 (16 U.S.C. Sec.1451 et seq.), or an equivalent compliance mechanism.

(B) Section 8 of the federal Reclamation Act of 1902.

(C) The federal Clean Water Act (33 U.S.C. Sec. 1251 et seq.).

(2) If the council adopts a Delta Plan pursuant to the federal Coastal Zone Management Act of 1972 (16 U.S.C. Sec. 1451 et seq.), the council shall submit the Delta Plan for approval to the United States Secretary of Commerce pursuant to that act, or to any other federal official assigned responsibility for the Delta pursuant to a federal statute enacted after January 1, 2010.

85300(a) The Delta Plan shall include subgoals and strategies to assist in guiding state and local agency actions related to the Delta.

85302(e) The following subgoals and strategies for restoring a healthy ecosystem shall be included in the Delta Plan:

(1) Restore large areas of interconnected habitats within the Delta and its watershed by 2100.

(2) Establish migratory corridors for fish, birds, and other animals along selected Delta river channels.

(3) Promote self-sustaining, diverse populations of native and valued species by reducing the risk of take and harm from invasive species.

(4) Restore Delta flows and channels to support a healthy estuary and other ecosystems.

(5) Improve water quality to meet drinking water, agriculture, and ecosystem long-term goals.

(6) Restore habitat necessary to avoid a net loss of migratory bird habitat and, where feasible, increase migratory bird habitat to promote viable populations of migratory birds.

85300(a) The Delta Plan may also identify specific actions that state or local agencies may take to implement the subgoals and strategies.

85302(a) Implementation of the Delta Plan shall further the restoration of the Delta ecosystem and a reliable water supply.

85302(b) The Delta Plan may include recommended ecosystem projects outside the Delta that will contribute to achievement of the coequal goals.

85302(c) The Delta Plan shall include measures that promote all of the following characteristics of a healthy Delta ecosystem:

(1) Viable populations of native resident and migratory species.

(2) Functional corridors for migratory species.

(3) Diverse and biologically appropriate habitats and ecosystem processes.

(4) Reduced threats and stresses on the Delta ecosystem.

(5) Conditions conducive to meeting or exceeding the goals in existing species recovery plans and state and federal goals with respect to doubling salmon populations.

85302(d) The Delta Plan shall include measures to promote a more reliable water supply that address all of the following:

(1) Meeting the needs for reasonable and beneficial uses of water.

(2) Sustaining the economic vitality of the state.

(3) Improving water quality to protect human health and the environment.

85302(h) The Delta Plan shall include recommendations regarding state agency management of lands in the Delta.

85303 The Delta Plan shall promote statewide water conservation, water use efficiency, and sustainable use of water.

85304 The Delta Plan shall promote options for new and improved infrastructure relating to the water conveyance in the Delta, storage systems, and for the operation of both to achieve the coequal goals.

85305(a) The Delta Plan shall attempt to reduce risks to people, property, and state interests in the Delta by promoting effective emergency preparedness, appropriate land uses, and strategic levee investments.

85305(b) The council may incorporate into the Delta Plan the emergency preparedness and response strategies for the Delta developed by the California Emergency Management Agency pursuant to Section 12994.5.

85306 The council, in consultation with the Central Valley Flood Protection Board, shall recommend in the Delta Plan priorities for state investments in levee operation, maintenance, and improvements in the Delta, including both levees that are a part of the State Plan of Flood Control and nonproject levees.

85307(a) The Delta Plan may identify actions to be taken outside of the Delta, if those actions are determined to significantly reduce flood risks in the Delta.

85307(b) The Delta Plan may include local plans of flood protection.

85307(c) The council, in consultation with the Department of Transportation, may address in the Delta Plan the effects of climate change and sea level rise on the three state highways that cross the Delta.

85307(d) The council, in consultation with the State Energy Resources Conservation and Development Commission and the Public Utilities Commission, may incorporate into the Delta Plan additional actions to address the needs of Delta energy development, energy storage, and energy distribution.

85308 The Delta Plan shall meet all of the following requirements:

(a) Be based on the best available scientific information and the independent science advice provided by the Delta Independent Science Board.

(b) Include quantified or otherwise measurable targets associated with achieving the objectives of the Delta Plan.

(c) Where appropriate, utilize monitoring, data collection, and analysis of actions sufficient to determine progress toward meeting the quantified targets.

(d) Describe the methods by which the council shall measure progress toward achieving the coequal goals.

(e) Where appropriate, recommend integration of scientific and monitoring results into ongoing Delta water management.

(f) Include a science-based, transparent, and formal adaptive management strategy for ongoing ecosystem restoration and water management decisions.

This page intentionally left blank.

CHAPTER 2

The Delta Plan

No single entity in California has the sole responsibility or authority for managing water supply and the Delta ecosystem. Instead, authority, expertise, and resources are spread out among a cadre of federal, State, and local agencies, with no single government agency empowered to provide leadership or a long-term vision. This is why governance reform enacted by the Delta Reform Act is fundamentally different from past approaches to managing the Delta. The milestone legislation created the Council, and gave it the direction and authority to serve two primary governance roles: (1) set a comprehensive, legally enforceable direction for how the State manages important water and environmental resources in the Delta through the adoption of a Delta Plan, and (2) ensure coherent and integrated implementation of that direction through coordination and oversight of State and local agencies proposing to fund, carry out, and approve Delta-related activities.

Recommended in significant part by the Delta Vision Task Force effort in 2008, this new approach is different from governance attempts over the past several decades that have tried, but largely failed, to provide effective and stable leadership. The *Delta Vision Strategic Plan* referred to some 200 agencies that play some role in managing the Delta's varied resources (Delta Vision 2008). One of the major goals articulated in that strategic plan was the establishment of a new governance structure with sufficient authority, responsibility, accountability, science support, and secure funding to achieve the coequal goals of providing a more reliable water supply for California and protecting, restoring, and enhancing the Delta ecosystem. The creation of the independent Council was a significant step toward implementing this goal. The Council is made up of seven members who provide a broad, statewide perspective and diverse expertise, and is advised by a 10-member board of nationally and internationally renowned scientists, the Delta Independent Science Board (ISB). The Delta Reform Act instructs the Council to "direct efforts across state agencies," but considerable challenges lie ahead in coordinating and supporting the multitude of agencies to achieve the goals of the Delta Plan.

The first major task for the newly created Council is the development of this Delta Plan. The Delta Reform Act requires the Council to develop and adopt a legally enforceable, long-term management plan for the Delta that uses best available science and is built upon the principles of adaptive management. The Delta Reform Act also established the Delta Science Program within the Council to provide the best possible unbiased scientific information to inform water and environmental decision making in the Delta. Because California's Delta is linked to so many statewide issues, described in Chapter 1, the Delta Plan's scope and purview encompasses statewide water use, flood management, and the Delta watershed, but with a specific focus on the legal Delta and Suisun Marsh. The Delta Plan contains a set of regulatory policies that will be enforced by the Council's appellate authority and oversight, described in this chapter. These regulatory policies and supporting documents are contained in Appendix B. The Delta Plan also contains priority recommendations, which are nonregulatory but call out actions essential to achieving the coequal goals. The Council has chosen to apply its regulatory authority in a targeted manner, and does so in an effort to ensure that all significant activities occurring in whole or in part in the Delta become better aligned over time with State policy priorities, including—and especially—the achievement of the coequal goals. The process for demonstrating compliance with Delta Plan policies is described in detail in this chapter.

In developing the first Delta Plan, the Council sought extensive public, stakeholder, and government agency input and, based on that input, developed the foundational set of policies and recommendations detailed in the following chapters to guide actions over the first few years of Plan implementation. Every stage of implementing the Delta Plan will necessitate leadership by the Council and ongoing coordination across a broad range of agencies, nongovernmental entities, and stakeholders.

The Delta Stewardship Council

As described in Chapter 1, the Delta of today is the result of centuries of natural and human-made actions and reactions. Government historically has worked to treat individual problems rather than adopt a systemwide approach. Dozens of agencies, task forces, and working groups have struggled to find the right combination of policy, science, and structure to address what are now California's fundamental goals for managing the Delta, the coequal goals.

The mission of the Council is to further the achievement of the coequal goals. To do so, the Council was charged with the development of a legally enforceable, long-term management plan for the Delta. To accomplish this, the Council will apply a common-sense approach based on a strong scientific foundation in an adaptive management framework to protect and restore the Delta ecosystem; improve the quality and reliability of California's water supplies; reduce risk to people, property, and State interests; and protect and enhance the Delta as an evolving place.

The Council's most important and challenging role is the facilitation, coordination, and integration of a range of actions and policies in support of the coequal goals. Implementation will occur through the Council's leadership of a formal Interagency Implementation Committee, ongoing informal staff-to-staff agency coordination, development of science to support the Delta Plan, and use of the Council's various authorities to ensure progress and accountability in how the Delta is managed. See Table 2-1 for a reference list of agencies with responsibilities in the Delta or related to the management of the Delta.

In addition to its role in setting State policy for the Delta in the Delta Plan, and in facilitating and coordinating agencies to achieve policy objectives, the Council was granted specific regulatory and appellate authority over certain actions that take place in whole or in part in the Delta. To do this, the Delta Plan contains a set of regulatory policies with which State and local agencies are required to comply. The Delta Reform Act specifically established a certification process for compliance with the Delta Plan. This means that State and local agencies that propose to carry out, approve, or fund a qualifying action in whole or in part in the Delta, called a "covered action," must certify that this covered action is consistent with the Delta Plan and must file a certificate of consistency with the Council that includes detailed findings. This process is described in the section "Covered Actions and Delta Plan Consistency" later in this chapter.

Agencies with Responsibilities in the Delta

TABLE 2-1

State	
Delta Stewardship Council	Established in 2009 by the Delta Reform Act to further the achievement of the coequal goals through the development and implementation of a legally enforceable Delta Plan.
California Department of Fish and Wildlife	Provides fish and wildlife protection and management, including management of wildlife areas and ecological reserves, public access, conservation planning, permitting, and implementation of the Ecosystem Restoration Program.
California Department of Water Resources	Owns and operates the State Water Project (which stores water upstream and conveys water through the Delta), has emergency response and flood planning responsibilities, holds water quality/supply contracts with Delta water agencies, and coordinates overall statewide water planning.
Delta Protection Commission	Prepares a comprehensive long-term resource management plan for land uses within the approximate 500,000-acre Primary Zone. Local government plans must be consistent.
Sacramento-San Joaquin Delta Conservancy	A primary State agency to implement ecosystem restoration in the Delta and also to assist/protect the region's agricultural, cultural, economic, and historical value.
State Water Resources Control Board	Required to develop in 2010 nonregulatory flow criteria for the Delta ecosystem necessary to protect public trust uses to inform planning proceedings for the Delta Plan and Bay Delta Conservation Plan (BDCP). Responsible for developing and implementing the Bay-Delta Water Quality Control Plan to establish water quality objectives, including flow objectives, to ensure reasonable protection of beneficial uses in the Bay-Delta. Responsible for establishing, implementing, and enforcing water right requirements to ensure the proper allocation and efficient use of water in and out of the Delta, including the role of the Delta Watermaster and implementation of the Bay-Delta Water Quality Control Plan. With regional boards, responsible for developing and implementing other water quality standards and control plans consistent with State and federal laws to reasonably protect aquatic beneficial uses.
California Emergency Management Agency	Plans, prepares emergency response, and coordinates the activities of all State agencies in connection to an emergency in the Delta; provides resources if local agencies are overwhelmed.
Central Valley Flood Protection Board	Plans flood control along the Sacramento and San Joaquin rivers and their tributaries in cooperation with the U.S. Army Corps of Engineers.
Office of the Delta Watermaster	Created in 2009 to oversee day-to-day administration of water rights, enforcement activities, and reports on water right activities regarding diversions in the Delta.
California Natural Resources Agency	Coordinates with a group of local water agencies, environmental and conservation organizations, State and federal agencies, and other interest groups developing the BDCP, a conservation strategy to be compliant with the Endangered Species Act (ESA) and Natural Community Conservation Planning Act, to be implemented over the next 50 years.
Other State agencies	Have various roles or responsibilities in the Delta relevant to the agency's concern (for example, California Department of Food and Agriculture, California Department of Transportation, California State Parks, California Department of Boating and Waterways, State Lands Commission, California Environmental Management Agency, and others).

Agencies with Responsibilities in the Delta

TABLE 2-1

Federal	
Bureau of Reclamation	Owns and operates the Central Valley Project, which, among other activities, pumps water through and out of the Delta.
U.S. Fish and Wildlife Service	Develops plans for the conservation and recovery of fish and wildlife resources, and addresses the variable needs of fish and wildlife pursuant to the ESA.
U.S. Army Corps of Engineers	Involved with both federal and nonfederal partners in assessing channel navigation, ecosystem, and flood risk management projects in the Delta. Works cooperatively with its nonfederal partners regarding the regulation, maintenance, and improvement of project levees in the Delta.
National Marine Fisheries Service	Develops plans for the conservation and recovery of salmonids in the Delta pursuant to the ESA.
U.S. Environmental Protection Agency	Responsible for protection and restoration of water quality in the Delta, pursuant to the Clean Water Act, which regulates the discharge of pollutants into waterways and sets standards for water quality. Oversees implementation of Clean Water Act programs and policies delegated to the State.
Other federal agencies	Various roles or responsibilities in the Delta relevant to the agency's concern (for example, U.S. Department of Agriculture, Natural Resources Conservation Service, and others).
Local	
Hundreds of local reclamation districts, resource conservation districts, water districts, city and county governments, and other special districts.	

DP-177

To be effective, governance to support science and implement adaptive management for a changing Delta must be flexible and have the capacity to change policies and practices in response to what is learned over time. An adaptive management approach as detailed in this chapter will ensure that the Delta Plan is updated as often as necessary to incorporate new information or modify policies and recommendations to ensure achievement of the coequal goals. The following section discusses the particular importance of science and adaptive management as they relate to the Delta.

Science and Adaptive Management in the Delta

The Delta Reform Act requires that the Delta Plan be based on and implemented using the best available science, and requires the use of science-based, transparent, and formal adaptive management strategies for ongoing ecosystem restoration and water management decisions. This section describes the importance of science, especially as it relates to the Delta, describes how the Delta Plan itself uses an adaptive management plan, and proposes the development of a Delta Science Plan as a companion to the Delta Plan.

The State of Bay-Delta Science report concluded that most of the decision making in the Delta was occurring on the basis of a false understanding that the Delta was a static system, and that "the Delta of the future would be much the same as the Delta of today" (Healey et al. 2008). Science indicates that significant changes are expected in the Delta over the coming decades, including climate change and the potential for earthquakes and flooding, as described in Chapter 1. In addition, current planning processes for habitat restoration, changes to water conveyance in the Delta, urban expansion, and other human drivers could reshape the Delta as we know it today.

The State of Bay-Delta Science urged a new perspective for decision making in the Delta (Healey et al. 2008). Decision making should be based on best available science, should account for risk and uncertainty, should acknowledge the dynamic nature of ecosystems, and should be responsive and adaptive to future change. The Delta Reform Act, enacted 1 year after that report, requires a strong science foundation for Council decisions. This includes the ongoing provision of scientific expertise to support the Council and other agencies through the Delta Science Program and Delta ISB. The Delta Science Program's mission is to provide the best possible scientific information for water and environmental decisions in the Bay-Delta system. The Delta ISB provides oversight of the scientific research, monitoring, and assessment programs that support adaptive management of the Delta to ensure that the application of the best science is used in Delta programs. The Delta ISB reviewed early drafts of this Delta Plan to ensure that the best science was used in the Delta Plan.

Why is it important that the Delta Plan emphasize science? First, science provides the basis of nearly all current understanding of the Delta's status (Healey et al. 2008, Lund et al. 2010). Second, new perspectives on science and policy in the Delta instill urgency for addressing the health of Delta ecosystems and the need for a more reliable water supply. Third, the interaction of multiple stressors to the ecosystem must be understood if they are to inform effective policy decisions.

Science and adaptive management are not simply academic exercises; they are tools that provide managers and decision makers an approach for using public funds more effectively, and increase the likelihood of success for a given project. Science by itself does not make or prioritize management decisions; it only informs actions and proposals. "Using the best science is only part of what is needed to resolve the competing interests…" that clamor over the Delta (NRC 2012).

The next sections describe what the Council means when it comes to best available science and adaptive management in the context of the coequal goals.

Best Available Science

Not all science is created equal nor deserves equal weight in decision making. Best available science provides the knowledge base for making sound decisions and is foundational for adaptive management. Best available science provides understanding for defining problems, developing conceptual models, identifying potential management actions, monitoring ecological and physical responses, and analyzing responses relative to the actions taken. Adaptive management both uses best available science and contributes to the creation of the best available science.

Best available science is specific to the decision being made and the time frame available for making that decision. There is no expectation of delaying decisions to wait for improved scientific understanding. Action may be taken on the basis of incomplete science if the information used is the best available at the time.

Best available science is developed through a process that meets the criteria of (1) relevance, (2) inclusiveness, (3) objectivity, (4) transparency and openness, (5) timeliness, and (6) peer review (NRC 2004). Best available science is consistent with the scientific process (Sullivan et al. 2006). Ultimately, best available science requires scientists using the best information and data to assist management and policy decisions. The processes and information used should be clearly documented and effectively communicated to foster improved understanding and decision making.

Under the Delta Plan, covered actions are required to demonstrate the use of best available science in their decision making (see policy G P1 in this chapter). Guidelines and criteria for identifying or developing best available science are provided in Appendix C.

SCIENCE IN THE DELTA – ADVANCES IN UNDERSTANDING

The following is a partial list of scientific advances that have changed understanding of the Delta and California's water supply over the last decade.

Effects of Climate Change on People and the Environment

- Increased frequency of (1) extreme water heights that cause floods, (2) water temperatures lethal to salmon and delta smelt, and (3) flooding in the Yolo Bypass, which will be much more common by the latter half of this century (Cloern et al. 2011).
- Trends in snowfall versus rainfall precipitation in the western United States show that temperatures have warmed during winter and early spring storms; and, consequently, the fraction of precipitation that falls as snow has declined while the fraction that falls as rain has increased. This shift from snowfall to rainfall will reduce natural water storage and is likely to increase risks of winter and spring flooding (Knowles et al. 2006).
- By mid-century, the Colorado River Reservoir System will not be able to meet all of the demands placed on it, including water supply for Southern California and the inland southwest, because reservoir levels will be reduced by over one-third and releases reduced by as much as 17 percent. Reductions in precipitation for the Colorado River Basin will threaten the ability to meet mandated water allocations (Barnett et al. 2004).

Water Supply Reliability

- The rate of groundwater depletion in the Central Valley was quantified using satellite imaging; approximately 2.5 million acre-feet per year of groundwater was lost during the period from October 2003 to March 2010 (Famiglietti et al. 2011).
- Precipitation and streamflow are proportionally more variable from year to year in California than in any other part of the United States (Dettinger et al. 2011).

Ecosystem Restoration

- Several open-water (pelagic) fish species have undergone steep declines known as the Pelagic Organism Decline (POD) (Sommer et al. 2007). The Interagency Ecological Program investigation of these declines led to new insights about the effects of multiple stressors on these species and the Delta ecosystem (summarized in Baxter et al. 2010). Improved knowledge about the POD also led to regulatory changes for water exports and pollutant discharges.
- In 86 percent of approximately 3,000 assessed streams across the United States, streamflow magnitudes (especially flow maxima and minima) were altered. In comparison to other evaluated stressors, streamflow alterations were found to have the greatest significance for explaining ecological impairment (Carlisle et al. 2011).
- Altered flow regimes by human activities influence the ecological impact of drought anomalies and increase the susceptibility of ecosystems to biological invasion. Extreme climatic events act together with environmental disturbances to enable the establishment of invasive species (Winder et al. 2011).
- Ratios of nutrients in Delta waters have been hypothesized to be a primary driver in the composition of aquatic food webs in the Bay-Delta (Glibert et al. 2011).

Water Quality

- Ammonium concentrations may be having a significant impact on phytoplankton composition and open-water food webs because of suppression of diatom blooms in the Bay-Delta (Dugdale et al. 2007).
- Pyrethroid pesticides largely derived from urban and suburban runoff are regularly found at levels that are toxic to aquatic invertebrates (Weston et al. 2005, Weston and Lydy 2010).

Risk Reduction

- With permanently flooded conditions and managed water depths, short-term sediment accretion rates as high as 7 to 9 centimeters per year can be obtained to help reverse subsidence on Delta islands (Miller et al. 2008).
- Atmospheric rivers (narrow corridors of concentrated moisture in the atmosphere) contribute 33 to 50 percent of the total average amount of rainfall for California and have been the source of many floods along the West Coast of the United States. California's water resources and floods come from the same storms to an extent, which makes integrated flood and water resources management all the more important (Dettinger et al. 2011).

DP-168

Adaptive Management

Adaptive management is defined in the Delta Reform Act as:

> *a framework and flexible decision making process for ongoing knowledge acquisition, monitoring, and evaluation leading to continuous improvements in management planning and implementation of a project to achieve specified objectives (Water Code section 85052).*

Adaptive management is useful in that it provides flexibility and feedback to manage natural resources in the face of often considerable uncertainty. This approach requires careful science-based planning followed by measurement to determine whether a given action actually achieves intended goals.

If goals are not achieved, informed adjustments can be made. This is especially important in the context of the Delta because, in some instances, competing and uncertain explanations arise, and decision making cannot be delayed until causes are better understood (Healey et al. 2008). The Council has adopted a three-phase adaptive management framework for the purposes of developing, implementing, and updating the Delta Plan, described later in this chapter, and also for use by ecosystem restoration and water management covered actions, as set forth in G P1 with additional detail in Appendix C.

A Delta Science Plan

Multiple frameworks for science in the Delta have been proposed, but a comprehensive science plan that specifies how scientific research, monitoring, analysis, and data management will be coordinated among entities has yet to be developed. Currently, science efforts in the Delta are performed by multiple entities with varying missions and mandates, and without an overarching plan. The National Research Council (NRC) found that "only a synthetic, integrated, analytical approach to understanding the effects of suites of environmental factors (stressors) on the ecosystem and its components is likely to provide important insights that can lead to enhancement of the Delta and its species" (NRC 2012). Therefore, a comprehensive science plan for the Delta is needed to organize and integrate ongoing scientific research, monitoring, and learning about the Delta as it changes over time.

A Delta Science Plan will guide efficient use of resources for balancing investments in addressing short-term science needs and those that build understanding over the long run. This plan will address effective governance for science in the Delta, strategies for addressing uncertainty and conflicting scientific information, the prioritization of research, near-term science needs, financial needs to support science, and more. Such a plan is essential to support the adaptive management of ecosystem restoration and water management decisions in the Delta.

Additional detail regarding the proposed Delta Science Plan is provided in recommendation G R1 in this chapter.

The Delta Plan

The Delta Reform Act established the Council and directed it to develop an overarching, long-term management plan for the Delta. Figure 2-1 shows the roles assigned to the Council under the Act. The Act specifically requires that this plan for the Delta include a science-based, formal adaptive management strategy for ongoing ecosystem restoration and water management decisions.

This section presents a three-phase adaptive management framework (Plan, Do, and Evaluate and Respond), describes specific considerations that went into the development of the Delta Plan, and provides the overarching framework for how the Council (in collaboration with others) will implement and continuously amend the Delta Plan to achieve the coequal goals.

Council Roles and the Delta Plan

Figure 2-1

The Council's Three-phase Adaptive Management Framework

Several existing frameworks for adaptive management provide the basis for the Delta Plan's own adaptive management approach.[1] Although there are differences among various frameworks, they generally consist of three broad phases: Plan, Do, and Evaluate and Respond. Throughout all three phases of the adaptive management process, decisions are made by managers, policy makers, and/or technical experts. In developing an adaptive management plan, the best available science should be used to inform all phases of the adaptive management process.

In addition to requiring adaptive management for certain proposed covered actions, the Council, in coordination with others, will use adaptive management to develop, implement, and update the Delta Plan. The Council will rely in large part on the Delta Science Program to determine the relevance, value, and reliability of the best available science and to organize that information for its use in the Council's decisions. The Council has the final responsibility for determining the best available science used in support of its actions, including when a choice among competing interpretations of available science must be made.

The three phases of the Council's adaptive management framework (Plan, Do, and Evaluate and Respond) are shown on Figure 2-2, and are further broken down into nine steps, which are described in detail in Appendix C.

The Delta Stewardship Council's Three-phase Adaptive Management Framework

Figure 2-2

[1] Christensen et al. 1996, Stanford and Poole 1996, CALFED Bay-Delta Program 2000, Habron 2003, Abal et al. 2005, Healey et al. 2008, Kaplan and Norton 2008, Bay Delta Conservation Plan Independent Science Advisors on Adaptive Management 2009, Williams et al. 2009.

Plan: Development of the Delta Plan

The first phase of adaptive management is "Plan." The Plan phase requires clear definition of the problem, establishment of objectives, how to achieve those objectives, and actions for implementation. Performance measures are included to evaluate whether the actions are successfully meeting their intended objectives. As described in Chapter 1, the Council was established in response to an ongoing crisis in the Delta. Water supply reliability and the health of the Delta ecosystem are both at risk, and the status quo—including the patchwork governance of State, local, and federal agencies—is not making acceptable progress toward reversing disturbing trends in a balanced and sustainable manner.

The Delta Plan is intended to be foundational and adaptive. It is foundational in that the Council has built on previous efforts, including CALFED, the Delta Vision, the California Water Plan, planning efforts of the State Water Resources Control Board (SWRCB), the Delta Protection Commission (DPC), and others. The framework established in this Delta Plan is intended to advance the coequal goals of water supply reliability and ecosystem health, and to employ adaptive management to improve the Plan over time.

This Delta Plan officially supersedes and replaces the Interim Delta Plan adopted by the Council on August 27, 2010.

Structure of the Delta Plan

The Delta Plan contains five core policy chapters (Chapters 3 through 7) and a chapter on Funding Principles to Support the Coequal Goals (Chapter 8). The narrative sections of each policy chapter provide subject matter context and rationale for the selection and implementation of core strategies. These core strategies are then broken down into actions: the policies and recommendations. The policies in the Delta Plan are regulatory in nature, and compliance is required for those who propose covered actions. In each policy chapter, the Policies and Recommendations section is followed by a section identifying both science needs and key issues for future evaluation by the Council.

Finally, each policy chapter concludes with a set of performance measures. The Delta Reform Act requires that the Delta Plan include performance measures to evaluate whether it is achieving its objectives over time. Information learned from performance measures will be an important part of how the Council determines when and how to update the Delta Plan as part of the Evaluate and Respond phase of the adaptive management process. See the sidebar, Performance Measures in the Delta Plan, later in this chapter.

Considerations in the Development of the Delta Plan

The Delta Reform Act set forth certain requirements and guidance for the development of the Delta Plan. The Act required the development of several State agency plans to inform the Delta Plan planning process and set forth statutory guidelines for the consideration or inclusion of certain plans, some of which were not yet completed at the date of Delta Plan publication and will be considered in future plan updates.

- **Delta Reform Act objectives.** The Act lists numerous objectives and, in some sections, provides detailed guidance for what the Delta Plan shall include (see Table 2-2).
- **State agency proposals.** Specific agencies are named in the Delta Reform Act as being responsible for submitting reports or recommendations to the Council for consideration for inclusion in the Delta Plan. The DPC, California State Parks, and the California Department of Food and Agriculture (CDFA) all submitted proposals that were considered in the development of this Delta Plan.
- **Consistency with federal law.** The Delta Reform Act requires that the Delta Plan be developed consistent with the federal Clean Water Act, Section 8 of the federal Reclamation Act of 1902, and the federal Coastal Zone Management Act of 1972 (CZMA), or an equivalent compliance mechanism. See sidebar, Federal Participation in Implementing the Delta Plan, for more information.

Delta Plan Requirements by Water Code Section

TABLE 2-2

Water Code Section	Requirement
85211	The Delta Plan shall include performance measurements that will enable the council to track progress in meeting the objectives of the Delta Plan. The performance measurements shall include, but need not be limited to, quantitative or otherwise measurable assessments of the status and trends in all of the following:
85211(a)	– The health of the Delta's estuary and wetland ecosystem for supporting viable populations of aquatic and terrestrial species, habitats, and processes, including viable populations of Delta fisheries and other aquatic organisms.
85211(b)	– The reliability of California water supply imported from the Sacramento River or the San Joaquin River watershed.
85300(a)	The Delta Plan shall include subgoals and strategies to assist in guiding state and local agency actions related to the Delta.
85302(e)	The following subgoals and strategies for restoring a healthy ecosystem shall be included in the Delta Plan:
85302(e)(1)	– Restore large areas of interconnected habitats within the Delta and its watershed by 2100.
85302(e)(2)	– Establish migratory corridors for fish, birds, and other animals along selected Delta river channels.
85302(e)(3)	– Promote self-sustaining, diverse populations of native and valued species by reducing the risk of take and harm from invasive species.
85302(e)(4)	– Restore Delta flows and channels to support a healthy estuary and other ecosystems.
85302(e)(5)	– Improve water quality to meet drinking water, agriculture, and ecosystem long-term goals.
85302(e)(6)	– Restore habitat necessary to avoid a net loss of migratory bird habitat and, where feasible, increase migratory bird habitat to promote viable populations of migratory birds.
85300(a)	The Delta Plan may also identify specific actions that state or local agencies may take to implement the subgoals and strategies.
85302(a)	Implementation of the Delta Plan shall further the restoration of the Delta ecosystem and a reliable water supply.
85302(b)	The Delta Plan may include recommended ecosystem projects outside the Delta that will contribute to achievement of the coequal goals.
85302(c)	The Delta Plan shall include measures that promote all of the following characteristics of a healthy Delta ecosystem:
85302(c)(1)	– Viable populations of native resident and migratory species.
85302(c)(2)	– Functional corridors for migratory species.
85302(c)(3)	– Diverse and biologically appropriate habitats and ecosystem processes.
85302(c)(4)	– Reduced threats and stresses on the Delta ecosystem.
85302(c)(5)	– Conditions conducive to meeting or exceeding the goals in existing species recovery plans and state and federal goals with respect to doubling salmon populations.
85302(d)	The Delta Plan shall include measures to promote a more reliable water supply that address all of the following:
85302(d)(1)	– Meeting the needs for reasonable and beneficial uses of water.
85302(d)(2)	– Sustaining the economic vitality of the state.
85302(d)(3)	– Improving water quality to protect human health and the environment.
85302(h)	The Delta Plan shall include recommendations regarding state agency management of lands in the Delta.

Delta Plan Requirements by Water Code Section

TABLE 2-2

Water Code Section	Requirement
85303	The Delta Plan shall promote statewide water conservation, water use efficiency, and sustainable use of water.
85304	The Delta Plan shall promote options for new and improved infrastructure relating to the water conveyance in the Delta, storage systems, and for the operation of both to achieve the coequal goals.
85305(a)	The Delta Plan shall attempt to reduce risks to people, property, and state interests in the Delta by promoting effective emergency preparedness, appropriate land uses, and strategic levee investments.
85305(b)	The council may incorporate into the Delta Plan the emergency preparedness and response strategies for the Delta developed by the California Emergency Management Agency pursuant to Section 12994.5.
85306	The council, in consultation with the Central Valley Flood Protection Board, shall recommend in the Delta Plan priorities for state investments in levee operation, maintenance, and improvements in the Delta, including both levees that are a part of the State Plan of Flood Control and nonproject levees.
85307(a)	The Delta Plan may identify actions to be taken outside of the Delta, if those actions are determined to significantly reduce flood risks in the Delta.
85307(b)	The Delta Plan may include local plans of flood protection.
85307(c)	The council, in consultation with the Department of Transportation, may address in the Delta Plan the effects of climate change and sea level rise on the three state highways that cross the Delta.
85307(d)	The council, in consultation with the State Energy Resources Conservation and Development Commission and the Public Utilities Commission, may incorporate into the Delta Plan additional actions to address the needs of Delta energy development, energy storage, and energy distribution.
85308	The Delta Plan shall meet all of the following requirements:
85308(a)	– Be based on the best available scientific information and the independent science advice provided by the Delta Independent Science Board.
85308(b)	– Include quantified or otherwise measurable targets associated with achieving the objectives of the Delta Plan.
85308(c)	– Where appropriate, utilize monitoring, data collection, and analysis of actions sufficient to determine progress toward meeting the quantified targets.
85308(d)	– Describe the methods by which the council shall measure progress toward achieving the coequal goals.
85308(e)	– Where appropriate, recommend integration of scientific and monitoring results into ongoing Delta water management.
85308(f)	– Include a science-based, transparent, and formal adaptive management strategy for ongoing ecosystem restoration and water management decisions.

- **Incorporation of the Bay Delta Conservation Plan into the Delta Plan.** The Bay Delta Conservation Plan (BDCP) is a major project considering large-scale improvements in water conveyance and large-scale ecosystem restoration in the Delta. When completed, it must be incorporated into the Delta Plan if it meets certain statutory requirements. Completion of the BDCP process and the number of projects now under consideration in that process would have large impacts on the Delta and would affect the coequal goals. (More detailed discussions of the BDCP are provided in Chapters 3 and 4.) The Delta Reform Act describes a separate, explicit process for incorporating the BDCP into the Delta Plan (Water Code section 85320), and the

Council has adopted administrative procedures governing appeals to the Council related to BDCP incorporation (see Appendix D). If the BDCP is incorporated into the Delta Plan, it becomes part of the Delta Plan and, therefore, part of the basis for future consistency determinations.

- **Incorporation of other plans into the Delta Plan.** The Council may incorporate other plans or programs in whole or in part into the Delta Plan to the extent that they promote the coequal goals.

Do: Implementation and Oversight of the Delta Plan

The second phase of adaptive management is "Do." The "doing," or implementation, of the Delta Plan will occur over time (through 2100) through the coordinated efforts of many State, local, and federal agencies, in cooperation with nongovernmental organizations and private parties, and Council oversight and exercise of appellate authorities.

Federal participation in implementing the Delta Plan and the coequal goals is described in detail in the sidebar, Federal Participation in Implementing the Delta Plan.

The Council is responsible for overseeing the Delta Plan's implementation. Given the numerous government agencies that frequently have conflicting or overlapping jurisdictional and programmatic interest in Delta matters (see Table 2-1), there is a compelling need for the Council to fulfill the role as integrator of Delta policy and coordinator of actions. This integration and coordination will occur through convening a formal Interagency Implementation Committee, providing ongoing informal staff-to-staff agency coordination, providing comments and advice from the Council to other agencies on proposed or ongoing plans and programs, holding public hearings, developing science to support the Delta Plan, and using the Council's appellate authority over consistency of significant actions in the Delta with the Delta Plan.

Delta Plan Interagency Implementation Committee

Perhaps the most significant tool the Council will have for implementing the Delta Plan and ensuring accountability is a formal method for active agency coordination. The Delta Reform Act directs the Council to establish and oversee a committee of agencies responsible for implementing the Delta Plan. Notably, the law states that "each agency shall coordinate its actions pursuant to the Delta Plan with the Council and other relevant agencies" (Water Code section 85204). Governance challenges have long plagued management of the Delta and California's ability to achieve stated objectives for water supply and the Delta ecosystem. Ambiguous and sometimes conflicting authorities and responsibilities among agencies thwart real progress (NRC 2012).

The Council, therefore, will coordinate implementation of the Delta Plan through the establishment and leadership of an Interagency Implementation Committee to do the following:

- Monitor progress of priority actions and agency activities to implement the Delta Plan;
- Report regularly on implementation plans and actions;
- Identify opportunities for integration and leveraging of funding;
- Identify funding needs and support development of a finance plan to implement the Delta Plan;
- Assist in the ongoing development and tracking of Delta Plan performance measures;
- Coordinate regulatory actions on significant projects to implement the Delta Plan, as appropriate; and
- Discuss common issues and resolve interagency conflicts.

The Interagency Implementation Committee, which shall convene at least twice each year and more often as needed, will be overseen by the Council and will be organized around the implementation of the Delta Plan. The Interagency Implementation Committee will include federal, local, and State agency representatives as dictated by the specific matter or subject area in the Delta Plan. At a minimum, the Interagency Implementation Committee will consist of the Council's Executive Officer, the Delta Science Program lead

FEDERAL PARTICIPATION IN IMPLEMENTING THE DELTA PLAN

The Delta Reform Act recognizes the federal government's critical role in achieving the coequal goals through the Delta Plan's comprehensive, Delta-wide planning and implementation effort. This effort goes beyond federal participation in the more narrowly focused BDCP. This recognition builds upon the history of federal-State cooperative governance efforts in the Delta made necessary by the multitude of federal and State agencies working on interconnected, cross-jurisdictional issues in and related to the Delta, including water project operations, water quality regulation, levee maintenance, habitat restoration, and endangered species regulation.

Federal Law Now Incorporates the Coequal Goals

The federal Energy and Water Development Appropriations Act of 2012 (Title II of the Consolidated Appropriations Act of 2012 (PL 112-074)) contains, in pertinent part, the following:

> *The Federal policy for addressing California's water supply and environmental issues related to the Bay-Delta shall be consistent with State law, including the coequal goals of providing a more reliable water supply for the State of California and protecting, restoring, and enhancing the Delta ecosystem…Nothing herein modifies existing requirements of Federal law. (Section 205)*

The Council's staff will work with federal agency representatives to explore opportunities for federal participation in Delta Plan implementation efforts to help those agencies comply with this new Congressional policy directive.

The current regulatory provisions of the Delta Plan, including the consistency review and appeals process, apply to only covered actions of State and local agencies. However, once the Delta Plan is adopted, the Delta Reform Act requires the Council to pursue a compliance mechanism that requires consistency of federal actions. The Delta Reform Act identifies the CZMA, or "an equivalent compliance mechanism," as the preferred means to accomplish this objective. Under the CZMA, states are authorized to review certain activities of federal agencies, including activities directly conducted by federal agencies and activities permitted or licensed by these agencies, for consistency with a state's federally approved coastal management program. This review authority applies to any activity that affects any land or water use or natural resource of the state coastal zone.

In this regard, the Council staff has met, and will continue to meet, with federal agency representatives to identify the appropriate process to submit the Delta Plan to the Secretary of Commerce for approval under the CZMA (and with representatives of the California Coastal Commission and the San Francisco Bay Conservation and Development Commission, which administer California's coastal management program).

DP-181

scientist, and executive officers or directors from the California Department of Water Resources (DWR); California Department of Fish and Wildlife (DFW); SWRCB and regional water quality control boards; the San Francisco Bay Conservation and Development Commission; the California Water Commission; the Sacramento-San Joaquin Delta Conservancy; the DPC; the Delta Watermaster; the CDFA; the Natural Resources Agency; the Business, Transportation and Housing Agency; and the California Environmental Protection Agency. Federal agencies such as National Oceanic and Atmospheric Administration Fisheries, U.S. Fish and Wildlife Service, Bureau of Reclamation, Natural Resources Conservation Service, U.S. Geological Survey, U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, and others, as appropriate, will be invited to participate and provide status reports on various projects and programs related to Delta Plan implementation.

The meetings of the Interagency Implementation Committee will be open to the public, and the agenda will be noticed in advance. The committee will create ad hoc workgroups as appropriate to facilitate focus on specific issues. Stakeholder representatives will be encouraged to participate in the various workgroups. The work of both the formal Interagency Implementation Committee and the workgroups may be supplemented with meetings or hearings conducted by the Council.

The Delta Protection Commission's Role in Delta Plan Implementation

The Delta Protection Act states that the DPC is the appropriate agency to identify and provide recommendations to the Council on methods of preserving the Delta as an evolving place. The DPC developed and submitted a set of recommendations to the Council, many of which were incorporated in this Delta Plan (DPC 2012). The Delta Protection Act outlines a process for the DPC to review and provide comments and recommendations to the Council on any significant project or proposed project within the scope of the Delta Plan that may affect the unique values of the Delta (Public Resources Code section 29773(a)). The Council's adopted procedures include a process whereby the Council will notify the DPC of covered action appeals.

Other Delta Plan Implementation Actions

In addition to convening the Interagency Implementation Committee and carrying out the other responsibilities assigned to it by the Delta Reform Act, the Delta Plan assigns other tasks that will further refine the Delta Plan to the Council. These tasks are described in the following recommendations: G R1 (Chapter 2), WR R5 (Chapter 3), WR R15 (Chapter 3), DP R7 (Chapter 5), DP R19 (Chapter 5), RR R4 (Chapter 7), and FP R1 through R3 (Chapter 8).

Additional Council Authorities in Implementing the Delta Plan

The Delta Reform Act enumerated a range of specific authorities for the Council related to the implementation of the Delta Plan (as shown on Figure 2-1). A full list of authorities can be found in Water Code section 85210 and in various sections of the Delta Reform Act. In implementing the Delta Plan, the Council has the authority to:

- **Comment on environmental impact reports.** The Council has a role in commenting on any State agency environmental impact reports (EIRs) as appropriate to the mission of the Council.
- **Comment on policies related to the coequal goals and implementation of the Delta Plan.** As appropriate, the Council may comment formally on any proposed policies or regulations that will impact the achievement of the coequal goals and the implementation of the Delta Plan.
- **Advise local governments.** The Council has a role in advising local and regional planning agencies regarding the consistency of their planning documents with the Delta Plan. As described in Chapter 5, the Council will review sustainable community strategies and regional transportation plans to prevent conflicts with the Delta Plan and to coordinate metropolitan development with actions in the Delta.
- **Request reports from State, federal, and local agencies.** The Council has the authority to request reports from agencies on issues related to the implementation of the Delta Plan.
- **Hold hearings.** The Council has the authority to hold hearings in all parts of the state and to subpoena witnesses.
- **Develop, coordinate, and promote the use of science through the Delta Science Program.** The Council has a role in providing the best available unbiased scientific information to inform water and environmental decision making in the Delta by funding research, synthesizing and communicating scientific information to policy makers and decision makers, promoting independent peer review, and coordinating with Delta agencies to promote science-based adaptive management.
- **Make consistency determinations upon appeal.** The Legislature intended that State and local actions that would have a significant impact on the coequal goals or a government-sponsored flood control program be consistent with the Delta Plan. The Council has the authority to implement the Delta Plan in part through the enforcement of consistency of covered actions with the Delta Plan upon appeal. The Delta Reform Act also gave the Council a specific appellate role with respect to the BDCP and its future incorporation into the Delta Plan. The Council's appellate roles, the definition of a covered action, and the consistency determination process and appeals process are described in detail in the Covered Actions and Delta Plan Consistency section later in this chapter.

Monitoring Progress toward Achieving the Coequal Goals

The Council will use existing monitoring efforts (such as the efforts of the Interagency Ecological Program, California Water Quality Monitoring Council, and California Statewide Groundwater Elevation Monitoring) and new monitoring efforts to inform progress toward achieving the performance measures in the Delta Plan. The Council will monitor the progress of programs and projects toward achieving the administrative, output, and outcome performance measures in the current Delta Plan and those developed in the future. Working with others, in particular the Interagency Implementation Committee, the Council will use coordinated information about relevant status and trends and progress toward meeting the coequal goals to inform revisions to the Delta Plan. The Council's monitoring activities will be reported on the Council website.

Evaluate and Respond: Updating and Amending the Delta Plan

The third phase of Delta Plan adaptive management is "Evaluate and Respond." According to the Delta Reform Act, the Council must review the Delta Plan at least once every 5 years and can revise it as the Council deems appropriate. This authority is consistent with the Council's obligation to base the Delta Plan on the best available scientific information and to use an adaptive management approach in updating the Plan as new information becomes available.

When updating the Delta Plan, the Council will consider information from other adaptive management activities in the Delta; evaluation of Delta Plan policies and recommendations; performance measures; other completed plans related to the Delta; and coordination, hearings, and oversight. The Council will rely in large part on the Delta Science Program for determining the relevance, value, and reliability of the best available science, and organizing that information for its use in the Council's decisions. The Council has the final responsibility for determining the best available science used in support of its actions, including when a choice among competing interpretations of available science must be made.

Reporting on Delta Plan Performance Measures

This Delta Plan contains preliminary performance measures developed to monitor performance of Delta Plan policies and recommendations. (See sidebar, Performance Measures in the Delta Plan, for more detailed information.) Upon adoption of the Delta Plan, staff will take the lead, working with scientific, agency, and stakeholder experts to continue to refine the Delta Plan's performance measures. Delta Plan performance measures will be periodically reviewed by independent expert review panels and will be sent to the Delta ISB for further review and comment. The resulting updated performance measures will be developed no later than December 31, 2014, for consideration by the Council for incorporation into the Delta Plan. The Council will issue periodic public reports on the status of performance measures.

Data collection related to the Delta and water management in California is already occurring, although more is needed. The Council, through the Interagency Implementation Committee and working with stakeholders, will report regularly on Delta Plan performance measures and the Delta Plan's progress in advancing the coequal goals. These reports will be made available to the public.

PERFORMANCE MEASURES IN THE DELTA PLAN

The performance measures included in this Delta Plan are primarily administrative measures focused on implementation of near-term actions (generally, actions contained within policies and recommendations of the Delta Plan) that support the coequal goals. This initial set of performance measures will be expanded and refined after adoption of the Delta Plan and will be considered for inclusion in subsequent updates of the Delta Plan.

Delta Plan performance measures have been placed into three general classes:

- Administrative performance measures describe decisions made by policy makers and managers to finalize plans or approve resources (funds, personnel, projects) for implementation of a program or group of related programs.
- Output (also known as "driver") performance measures evaluate the factors that may be influencing outcomes and include on-the-ground implementation of management actions, such as acres of habitat restored or acre-feet of water released, as well as natural phenomena outside of management control (such as a flood, earthquake, or ocean conditions).
- Outcome performance measures evaluate responses to management actions or natural outputs.

Administrative performance measures are included in Appendix E. Output and outcome performance measures, where appropriate, are included at the end of individual chapters.

Development of informative and meaningful performance measures is a challenging task that will continue after the adoption of the Delta Plan. Performance measures need to be designed to capture important trends and to address whether specific actions are producing expected results. Efforts to develop performance measures in complex and large-scale systems like the Delta are commonly multiyear endeavors. The Council will improve all performance measures, but will focus on outcome measures through a multiyear effort, using successful approaches for developing performance measures employed by similar efforts elsewhere (such as the Kissimmee River Restoration, The State of San Francisco Bay, and Healthy Waterways Southeast Queensland, Australia) as positive examples (see Appendix C for more information).

DP-301

Communication and the Delta Plan

Keeping the public and decision makers informed as future Delta Plan changes are proposed and considered is a vital step. The Council is committed to open communication of current understanding gained through the evaluation of performance measures, monitoring, science, and adaptive management. This communication will be continuous as the Council receives and produces information that will be used to adapt its strategy toward meeting the coequal goals and updating the Delta Plan.

The Council's website and meetings will remain the central hub for communicating information about progress toward meeting the coequal goals and the objectives of the Delta Plan. Information learned from the analysis, synthesis, and evaluation of how well the policies and recommendations in the Delta Plan are meeting their intended goals will be gathered and communicated through a number of media and forums that may include:

- The Council's meetings and workshops, website, social media, and newsletter
- Staff reports on the status and trends of the Delta Plan performance measures
- Reports, presentations, and correspondence presented to the Council
- Interagency Implementation Committee meetings and products
- The Delta Science Program website, *Science News*; the online journal, *San Francisco Estuary & Watershed Science*; brown bag seminars; and Biennial Bay-Delta Science Conference
- Delta ISB meetings and products

Covered Actions and Delta Plan Consistency

The Delta Reform Act directs the Council to develop a legally enforceable long-term management plan for the Delta (this Delta Plan) and includes a mechanism for enforcement of Delta Plan policies over State and local actions identified as covered actions (Water Code sections 85001(c) and 85022). The Council has taken a hybrid approach to developing the Delta Plan by including both regulatory policies and nonregulatory recommendations. This section presents a discussion of the process and general requirements for certifying consistency with the Delta Plan through compliance with its regulatory policies, and includes examples of covered actions and exemptions.

Delta Plan regulatory policies are not intended and shall not be construed as authorizing the Council or any entity acting pursuant to this section to exercise their power in a manner that will take or damage private property for public use without the payment of just compensation. These policies are not intended to affect the rights of any owner of property under the Constitution of the State of California or the United States. None of the Delta Plan policies increases the State's flood liability.

Covered Actions Must Comply with Delta Plan Policies

The Delta Reform Act requires State and local actions that fit the legal definition of a covered action to be consistent with the policies included in the Delta Plan. The mechanism for determining consistency is the filing of a certification of consistency. Not all actions that occur in whole or in part in the Delta are covered actions. Only certain activities qualify as covered actions, and the Delta Reform Act establishes specific criteria and exclusions, discussed in this chapter. Furthermore:

- The State or local agency that carries out, approves, or funds a proposed action determines whether that proposed plan, program, or project is a covered action (subject to judicial review of whether the determination was reasonable and consistent with the law).
- The State or local agency that carries out, approves, or funds a covered action ("proponents") needs to certify consistency with the policies included in the Delta Plan.
- In the case of all other actions (those that do not meet the criteria of being a covered action or are otherwise explicitly excluded), the Delta Plan's policies, where applicable, are recommendations.

What Is a Covered Action?

For a State or local agency to determine whether its proposed plans, programs, or projects are covered actions under the Delta Plan and, therefore, subject to the regulatory provisions in the plan, it must start with the Delta Reform Act, which defines a covered action as (Water Code section 85057.5(a)):

> *…a plan, program, or project as defined pursuant to Section 21065 of the Public Resources Code that meets all of the following conditions:*
>
> 1. *Will occur, in whole or in part, within the boundaries of the Delta or Suisun Marsh;*
> 2. *Will be carried out, approved, or funded by the state or a local public agency;*
> 3. *Is covered by one or more provisions of the Delta Plan;*
> 4. *Will have a significant impact on the achievement of one or both of the coequal goals or the implementation of government-sponsored flood control programs to reduce risks to people, property, and state interests in the Delta.*

Figure 2-3 shows the steps to follow for identifying whether a proposed plan, project, or program is a covered action.

Screening Criteria for Covered Actions

As used in this Delta Plan, the statutory criteria for covered actions under the Delta Plan are collectively referred to as "screening criteria." Before using the screening criteria, a project proponent should first determine whether its proposed plan, program, or project is exempt from covered action status under either the Council's administrative exemptions or the Delta Reform Act's statutory exemptions, discussed below. Early consultation with Council staff is encouraged and can assist in this determination.

1. **Is a "Project," as defined by section 21065 of the Public Resources Code.** A proponent's first step in determining whether a plan, program, or project is a covered action is to identify whether it meets the definition of a project as defined in Public Resources Code section 21065. That particular provision is the section of the California Environmental Quality Act (CEQA) that defines the term "project" for purposes of potential review under CEQA.[2] If the plan, program, or project does indeed meet the definition of a project under CEQA, the next step in determining a covered action is to review the four additional screening criteria in the definition of covered action, *all* of which must be met by a proposed plan, program, or project for it to qualify as a covered action (see sidebar, What Does CEQA Consider a "Project"?).

2. **Will occur in whole, or in part, within the boundaries of the Delta or Suisun Marsh.** To qualify as a covered action, a project must include one or more activities that take place at least partly within the Delta or Suisun Marsh. This means, for example, that the diversion and use of water in the Delta watershed that is entirely upstream of the statutory Delta or Suisun Marsh would not satisfy this criterion. By contrast, this criterion *would* be met if water intended for use upstream were transferred through the statutory Delta or Suisun Marsh (pursuant, for example, to a water transfer longer than 1 year in duration).

Decision Tree for State and Local Agencies on Possible Covered Actions

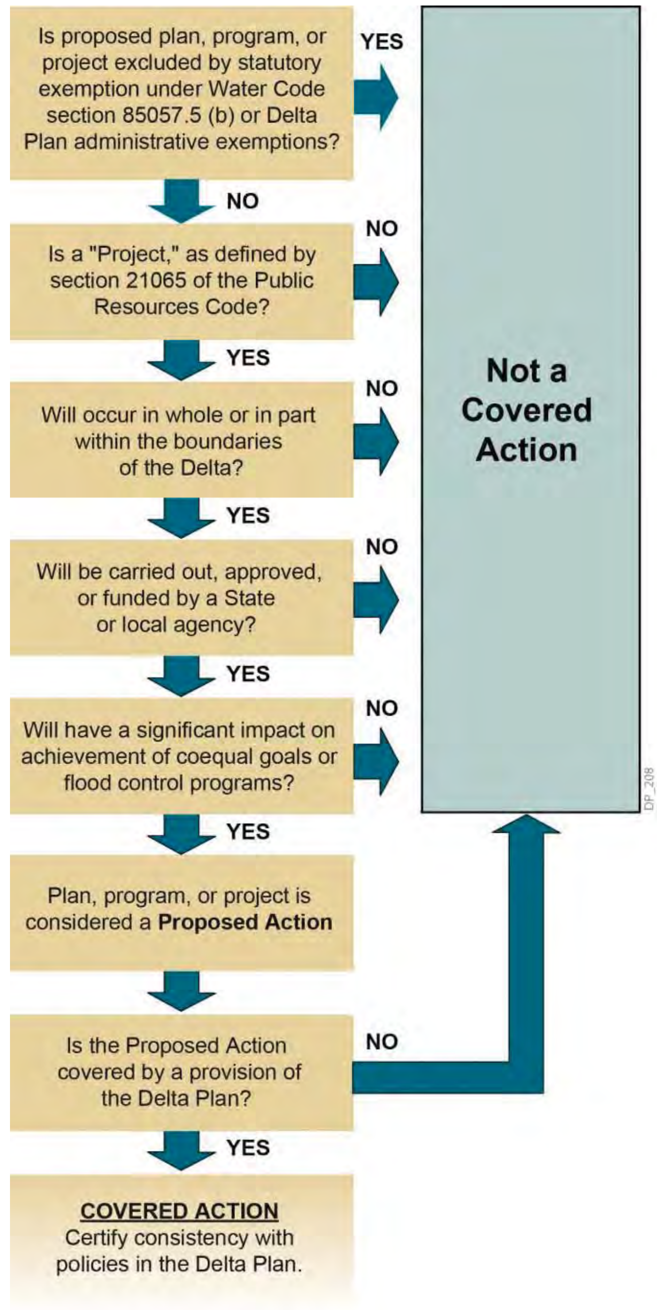


Figure 2-3

[2] It is important to note that CEQA's various statutory and categorical exemptions—which are considered only after the threshold determination of a CEQA "project" is made—are not similarly incorporated by cross-reference in the definition of covered action. Therefore, the Delta Plan must expressly incorporate a CEQA exemption for it to apply to the Delta Plan.

3. **Will be carried out, approved, or funded by the State or a local public agency.** If these screening criteria are met, it is recommended that the "significant impact" criteria be analyzed next.

4. **Will have a significant impact on the achievement of one or both of the coequal goals or the implementation of a government-sponsored flood control program to reduce risks to people, property, and State interests in the Delta.** In addition, a proposed project must have a "significant impact" as defined under Water Code section 85057.5(a)(4) to qualify as a covered action. For this purpose, significant impact means a substantial positive or negative impact on the achievement of one or both of the coequal goals or the implementation of a government-sponsored flood control program to reduce risks to people, property, and State interests in the Delta, that is directly or indirectly caused by a project on its own or when the project's incremental effect is considered together with the impacts of other closely related past, present, or reasonably foreseeable future projects. The coequal goals and government-sponsored flood control programs are further defined in Chapters 3, 4, and 7.

   The following categories of projects will not have a significant impact for this purpose:

   - "Ministerial" projects exempted from CEQA, pursuant to Public Resources Code section 21080(b)(1);
   - "Emergency" projects exempted from CEQA, pursuant to Public Resources Code section 21080(b)(2) through (4);
   - Temporary water transfers of up to 1 year in duration. This provision shall remain in effect only through December 31, 2016, and as of January 1, 2017, is repealed, unless the Council acts to extend the provision prior to that date. The Council contemplates that any extension would be based upon DWR and the SWRCB's participation with stakeholders to identify and implement transfer measures, as recommended in WR R15;
   - Other projects exempted from CEQA, unless there are unusual circumstances indicating a reasonable possibility that the project will have a significant impact under Water Code section 85057.5(a)(4). Examples of unusual circumstances could arise in connection with, among other things:
     - Local government general plan amendments for the purpose of achieving consistency with the DPC's Land Use and Resource Management Plan; and
     - Small-scale habitat restoration projects, as referred to in CEQA Guidelines, section 15333 of Title 14 of the California Administrative Code, proposed in important restoration areas, but which are inconsistent with the Delta Plan's policy related to appropriate habitat restoration for a given land elevation.

WHAT DOES CEQA CONSIDER A "PROJECT"?

Public Resources Code section 21065 (which is incorporated by reference in the Delta Reform Act) defines the term "project" in the following manner:

> *21065. "Project" means an activity which may cause either a direct physical change in the environment, or a reasonably foreseeable indirect physical change in the environment, and which is any of the following:*
>
> *(a) An activity directly undertaken by any public agency.*
>
> *(b) An activity undertaken by a person which is supported, in whole or in part, through contracts, grants, subsidies, loans, or other forms of assistance from one or more public agencies.*
>
> *(c) An activity that involves the issuance to a person of a lease, permit, license, certificate, or other entitlement for use by one or more public agencies.*

DP-182

The Council will consider, as part of its ongoing adaptive management of the Delta Plan, whether these exemptions remain appropriate and/or whether the Delta Plan should be amended to include other types of projects.

If the above four screening criteria are met, then for purposes of the Delta Plan, the plan, program, or project is referred to as a "proposed action." Although a proposed action meets the first four screening criteria, the action has not yet been reviewed by the State or local agency to determine whether it meets the fifth screening criterion: is the proposed action covered by one or more Delta Plan policies? If the proposed action is covered by at least one Delta Plan regulatory policy, then the proposed action is a "covered action." If the proposed action is not covered by any Delta Plan regulatory policy, it is not a covered action.

5. **Is covered by one or more provisions of the Delta Plan.** This means that the proposed action must be covered by one or more regulatory policies contained in Chapters 3 through 7 of the Delta Plan. Each of those regulatory policies specifies the types of proposed actions that they cover. If the proposed action is covered by one or more provisions of the Delta Plan—the final criteria—the proposed action is, therefore, a covered action.

Statutory Exemptions

Certain actions are statutorily excluded from the definition of covered action and are exempt from the Council's regulatory authority (Water Code section 85057.5(b)). A complete list is included in Appendix F. These exemptions include:

- A regulatory action of a State agency (such as the adoption of a water quality control plan by the SWRCB, or the issuance of a California Endangered Species Act take permit by DFW)
- Routine maintenance and operation of the State Water Project or the Central Valley Project
- Routine maintenance and operation of any facility located, in whole or in part, in the Delta, that is owned or operated by a local public agency (such as routine maintenance of levees by a reclamation district)

Although a regulatory action by another State agency is not a covered action, the underlying action regulated by that agency can be a covered action (provided it otherwise meets the definition). The Council has concurrent jurisdiction over covered actions when that action is also regulated by another State agency. For example, the issuance of a California Endangered Species Act take permit by DFW is a regulatory action of a State agency and, therefore, is not a covered action. However, the underlying action requiring the take permit could be a covered action, and, if it is, it must be consistent with the Delta Plan's policies. Therefore, even when a covered action is regulated by another agency (or agencies), the covered action still must be consistent with the Delta Plan. In the situation where a covered action is governed by multiple agencies and laws, the action must comply with all relevant legal requirements.

Who Determines Whether a Proposed Plan, Program, or Project Is a Covered Action?

A State or local agency that proposes to carry out, approve, or fund a plan, program, or project is the entity that must determine whether that plan, program, or project is a covered action. That determination must be reasonable, made in good faith, and consistent with the Delta Reform Act and relevant provisions of this Plan. If requested, Council staff will meet with an agency's staff during early consultation to review consistency with the Delta Plan and to offer advice as to whether the proposed plan, program, or project appears to be a covered action, provided that the ultimate determination in this regard must be made by the agency. If an agency determines that a proposed plan, program, or project is not a covered action, that determination is not subject to Council regulatory review, but is subject to judicial review as to whether it was reasonable, made in good faith, and is consistent with the Delta Reform Act and relevant provisions of this Plan.

Mitigation of Significant Adverse Impacts on the Environment

Public Resources Code section 21081.6 requires a public agency to adopt a mitigation monitoring or reporting program (MMRP) to ensure compliance with the mitigation measures adopted by the agency at the time of project approval. The MMRP is a working implementation document to ensure that mitigation measures are implemented. The MMRP for the *Delta Plan Program Environmental Impact Report* (PEIR) ensures compliance with the Delta Plan mitigation measures. The Delta Plan MMRP lists the mitigation measures incorporated into the Delta Plan, when they need to be implemented, who is responsible for implementing them, and who reports on compliance. As specified in policy G P1 of the Delta Plan, any covered action that is not exempt must include either the mitigation measures identified in the Delta Plan's PEIR, if applicable and feasible; substitute mitigation measures that the proposing agency finds to be equally or more effective than those identified in the Delta Plan PEIR; or an explanation of why such mitigation is not feasible. Monitoring and/or reporting on implementation of the adopted Delta Plan mitigation measures will be accomplished through the certification of consistency process as part of the certification forms. The MMRP can be found on the DSC's website at http://deltacouncil.ca.gov/.

Certifications of Consistency

Once a State or local agency has determined that their plan, program, or project is a covered action under the Delta Plan, they are required to submit a written certification to the Council, with detailed findings, demonstrating that the covered action is consistent with the Delta Plan (Water Code section 85225 et seq.). Furthermore:

- The first policy in the Delta Plan, G P1, describes requirements to be included in the certification of consistency for all covered actions and is included in this chapter.
- The certification of consistency must be submitted to the Council prior to initiating implementation of the covered action.
- The certification of consistency should not be submitted to the Council until the covered action has been fully described and the impacts associated with the covered action have been identified; this coincides with the completion of the CEQA process.
- Should the covered action project change substantially, the agency will be required to submit a new certification of consistency to the Council.

The Council has developed a discretionary checklist that agencies may use to facilitate the process, as well as certification forms and related materials, available on the Council website.

Bay Delta Conservation Plan Covered Activity Consistency Certification

The Delta Reform Act describes a specific process for the potential incorporation of BDCP into the Delta Plan. If BDCP is incorporated, an agency proposing a qualifying "covered activity" under BDCP that also meets the statutory definition of a covered action must file a short form certification of consistency with findings indicating only that the covered action is consistent with the BDCP. Consistency for these purposes shall be presumed if the certification filed by the agency includes a statement to that effect from DFW.

Covered Action Consistency Appeals

In contrast to how many other governmental plans are implemented, the Council does *not* exercise direct review and approval authority over covered actions to determine their consistency with the regulatory policies in the Delta Plan. Instead, State or local agencies self-certify Delta Plan consistency, and the Council serves as an appellate body for those determinations.

Any person, including any member of the Council or its Executive Officer, who claims that a covered action is inconsistent with the Delta Plan and, as a result of that inconsistency, will have a significant adverse impact on the achievement of one or both of the coequal goals or implementation of government-sponsored flood control program, may file an appeal with regard to a certification of consistency submitted to Council.

The Council has appellate authority to determine the consistency of covered actions with the Delta Plan if they are challenged. The Council is required to apply the standard of substantial evidence when reviewing covered action appeals. State or local agencies are required to submit detailed findings upon filing their consistency determination, described previously. These findings and the record will provide the basis for the Council's decision making.

Per statute, an appeal must be filed within 30 days; if a valid appeal is filed, the Council is responsible for subsequent evaluation and determination—as provided in statute and the Council's Administrative Procedures Governing Appeals—of whether the covered action is consistent with the Delta Plan's policies. More than one policy in the Delta Plan may apply to a covered action. If no person appeals the certification of consistency, the State or local public agency may proceed to implement the covered action.

In the event of an appeal of a covered action, the Council may consult with the DPC consistent with Public Resources Code section 29773.

Upon receiving an appeal, the Council has 60 days to hear the appeal and an additional 60 days to make its decision and issue specific written findings. If the covered action is found to be inconsistent, the project may not proceed until it is revised so that it is consistent with the Delta Plan.

The appeals process is described in statute and further defined in the appeals procedures adopted by the Council; it is attached for reference purposes as Appendix D.

POLICIES AND RECOMMENDATIONS

State and local agencies approve many important plans, programs, and projects annually that are in or otherwise affect the Delta. Interagency coordination is often limited and, despite the Delta's special status, there are no overarching guidelines or coordinated best management practices to ensure that all significant actions use best available science or adaptive management in particular. The Delta Reform Act, in describing a process for coordinating actions under the Delta Plan, requires that State or local government actions are consistent with the Delta Plan and supported by detailed findings. Policy G P1 describes compliance requirements for covered actions that are to be included in the project proponent's written findings.

Problem Statement

Independent and disparate actions by individual agencies can lead to conflict and reduce successful achievement of the coequal goals. Lack of uniform use of best available science and adaptive management for water supply and ecosystem projects can lead to unintended consequences, reduced likelihood of project success, and increased likelihood of adverse environmental impacts. In addition, management actions can be delayed when uncertainty exists, while adaptive management allows for flexible decision making despite uncertainty.

In some cases, project proponents do not carefully plan for the resources and costs of monitoring and tracking, and full adaptive management does not occur. Failure of significant Delta-related actions to comply with existing law can thwart the successful achievement of the coequal goals.

Policies

The appendices referred to in the policy language below are included in Appendix B of the Delta Plan.

G P1. Detailed Findings to Establish Consistency with the Delta Plan

(a) This policy specifies what must be addressed in a certification of consistency filed by a State or local public agency with regard to a covered action. This policy only applies after a "proposed action" has been determined by a State or local public agency to be a covered action because it is covered by one or more of the policies contained in Article 3. Inconsistency with this policy may be the basis for an appeal.

(b) Certifications of consistency must include detailed findings that address each of the following requirements:

(1) Covered actions, in order to be consistent with the Delta Plan, must be consistent with this regulatory policy and with each of the regulatory policies contained in Article 3 implicated by the covered action. The Delta Stewardship Council acknowledges that in some cases, based upon the nature of the covered action, full consistency with all relevant regulatory policies may not be feasible. In those cases, the agency that files the certification of consistency may nevertheless determine that the covered action is consistent with the Delta Plan because, on whole, that action is consistent with the coequal goals. That determination must include a clear identification of areas where consistency with relevant regulatory policies is not feasible, an explanation of the reasons why it is not feasible, and an explanation of how the covered action nevertheless, on whole, is consistent with the coequal goals. That determination is subject to review by the Delta Stewardship Council on appeal;

(2) Covered actions not exempt from CEQA must include applicable feasible mitigation measures identified in the Delta Plan's Program EIR (unless the measure(s) are within the exclusive jurisdiction of an agency other than the agency that files the certification of consistency), or substitute mitigation measures that the agency that files the certification of consistency finds are equally or more effective;

(3) As relevant to the purpose and nature of the project, all covered actions must document use of best available science;

(4) Ecosystem restoration and water management covered actions must include adequate provisions, appropriate to the scope of the covered action, to assure continued implementation of adaptive management. This requirement shall be satisfied through both of the following:

(A) An adaptive management plan that describes the approach to be taken consistent with the adaptive management framework in Appendix 1B, and

(B) Documentation of access to adequate resources and delineated authority by the entity responsible for the implementation of the proposed adaptive management process.

(c) A conservation measure proposed to be implemented pursuant to a natural community conservation plan or a habitat conservation plan that was:

(1) Developed by a local government in the Delta; and

(2) Approved and permitted by the California Department of Fish and Wildlife prior to May 16, 2013

is deemed to be consistent with sections 5005 through 5009 of this Chapter if the certification of consistency filed with regard to the conservation measure includes a statement confirming the nature of the conservation measure from the California Department of Fish and Wildlife.

23 CCR Section 5002
NOTE: Authority cited: Section 85210(i), Water Code.
Reference: Sections 85225, 85225.10, 85020, 85054, 85302(g), and 85308, Water Code.

Problem Statement

Currently, science efforts related to the Delta are performed by multiple entities with multiple agendas and without an overarching plan for coordinating data management and information sharing among entities. Increasingly, resource management decisions are made in the courtroom as conflicting science thwarts decision making and delays action. Multiple frameworks for science in the Delta have been proposed, but a comprehensive science plan that organizes and integrates ongoing scientific research, monitoring, analysis, and data management among entities has yet to be fully formulated.

Recommendations

G R1. Development of a Delta Science Plan

The Delta Stewardship Council's Delta Science Program should develop a Delta Science Plan by December 31, 2013. The Delta Science Program should work with the Interagency Ecological Program, Bay Delta Conservation Plan, California Department of Fish and Wildlife, and other agencies to develop the Delta Science Plan. To ensure that best science is used to develop the Delta Science Plan, the Delta Independent Science Board should review the draft Delta Science Plan.

The Delta Science Plan should address the following:

- *A collaborative institutional and organizational structure for conducting science in the Delta*
- *Data management, synthesis, scientific exchange, and communication strategies to support adaptive management and improve the accessibility of information*
- *Strategies for addressing uncertainty and conflicting scientific information*
- *Prioritization of research and balancing of the short-term immediate science needs with science that enhances comprehensive understanding of the Delta system over the long term*
- *Identification of existing and future needs for refining and developing numerical and simulation models along with enhancing existing Delta conceptual models (e.g., the Interagency Ecological Program (IEP) Pelagic Organism Decline (POD) and the Delta Regional Ecosystem Restoration Implementation Plan (DRERIP) models)*
- *An integrated approach for monitoring that incorporates existing and future monitoring efforts*
- *An assessment of financial needs and funding sources to support science*

Timeline for Implementing Policies and Recommendations

Figure 2-4 lays out a timeline for implementing the policies and recommendations described in the previous section. The timeline emphasizes near-term and intermediate-term actions.

Timeline for Implementing Policies and Recommendations

TIMELINE CHAPTER 2: The Delta Plan

	ACTION (REFERENCE #)	LEAD AGENCY(IES)	NEAR TERM 2012–2017	INTERMEDIATE TERM 2017–2025
POLICIES	Detailed findings to establish consistency with the Delta Plan (G P1)	Varies	●	●
RECOMMENDATIONS	Development of a Delta Science Plan (G R1)	Council	●	
COUNCIL ACTIONS	Establish Delta Plan Interagency Implementation Committee	Council	●	●

DP_341

Agency Key:
Council: Delta Stewardship Council

Figure 2-4

References

Abal, E. G., S. E. Bunn, and W. C. Dennison, eds. 2005. *Healthy Waterways Healthy Catchments: Making the Connection in South East Queensland, Australia*. Moreton Bay Waterways and Catchments Partnership, Brisbane. p. 240.

Barnett, T., R. Malone, W. Pennell, D. Stammer, B. Semtner, and W. Washington. 2004. The effects of climate change on water resources in the west: Introduction and overview. *Climatic Change* 62:1-11.

Baxter, R., R. Breuer, L. Brown, L. Conrad, F. Feyrer, S. Fong, K. Gehrts, L. Grimaldo, B. Herbold, P. Hrodey, A. Mueller-Solger, T. Sommer, and K. Souza. 2010. *Interagency Ecological Program 2010 Pelagic Organism Decline Work Plan and Synthesis of Results*. Interagency Ecological Program for the San Francisco Estuary.

Bay Delta Conservation Plan Independent Science Advisors on Adaptive Management. 2009. *Bay Delta Conservation Plan Independent Science Advisor's Report on Adaptive Management*. Page 14. Site accessed May 2011. http://www.bdcpweb.com/Libraries/Background_Documents/BDCP_Adaptive_Management_ISA_report_Final.sflb.ashx.

CALFED Bay-Delta Program. 2000. *Ecosystem Restoration Program Plan: Strategic Plan for Ecosystem Restoration*. CALFED Bay-Delta Program: Sacramento, California. 75 pp.

Carlisle, D. M., D. M. Wolock, and M. R. Meador. 2011. Alteration of streamflow magnitudes and potential ecological consequences: a multiregional assessment. *Frontiers in Ecology and the Environment* 9(5): 264-270.

Christensen, N. L., A. M. Bartuska, J. H. Brown, S. Carpenter, C. D'Antonio, R. Francis, J. R. Franklin, J. A. MacMahon, R. R. Noss, D. J. Parsons, C. H. Peterson, M. G. Turner, and R. G. Woodmansee. 1996. The report of the Ecological Society of America committee on the scientific basis for ecosystem management. *Ecological Applications* 6:665-691.

Cloern, J. E., N. Knowles, L. R. Brown, D. Cayan, M. D. Dettinger, T. L. Morgan, D. H. Schoellhamer, M. T. Stacey, M. van der Wegen, R. W. Wagner, and A. D. Jassby. 2011. Projected evolution of California's San Francisco Bay-Delta-River system in a century of climate change. *PLoS ONE* 6:e24465.

DPC (Delta Protection Commission). 2012. *Proposal to Protect, Enhance, and Sustain the Unique Cultural, Historical, Recreational, Agricultural, and Economic Values of the Sacramento-San Joaquin Delta as an Evolving Place*. January 26.

Delta Vision (Delta Vision Blue Ribbon Task Force). 2008. *Delta Vision Strategic Plan*. October 17. http://deltavision.ca.gov/strategicplanningprocess/staffdraft/delta_vision_strategic_plan_standard_resolution.pdf.

Dettinger, M. D., F. M. Ralph, T. Das, P. J. Neiman, and D. R. Cayan. 2011. Atmospheric rivers, floods and the water resources of California. *Water* 3:445-478.

Dugdale, R. C., F. P. Wilkerson, V. E. Hogue, and A. Marchi. 2007. The role of ammonium and nitrate in spring bloom development in San Francisco Bay. *Estuarine, Coastal, and Shelf Science* 73:17-29.

Famiglietti, J. S., M. Lo, S. L. Ho, J. Bethune, K. J. Anderson, T. H. Syed, S. C. Swenson, C. R. de Linage, and M. Rodell. 2011. Satellites measure recent rates of groundwater depletion in California's Central Valley. *Geophysical Research Letters* 38, L03403, doi:10.1029/2010GL046442.

Glibert, P. M., D. Fullerton, J. M. Burkholder, J. C. Cornwell, and T. M. Kana. 2011. Ecological stoichiometry, biogeochemical cycling, invasive species, and aquatic food webs: San Francisco Estuary and comparative systems. *Reviews in Fisheries Science* 19:358-417.

Habron, G. 2003. Role of adaptive management for watershed councils. *Environmental Management* 31: 29-41.

Healey, M. C., M. D. Dettinger, and R. B. Norgaard, eds. 2008. *The State of Bay-Delta Science*. CALFED Science Program: Sacramento, California, 174 pp. Abstract. Sacramento, California.

Kaplan, R. S., and D. P. Norton. 2008. Mastering the management system. *Harvard Business Review* January: 62-57.

Knowles, N., M. D. Dettinger, and D. R. Cayan. 2006. Trends in snowfall versus rainfall in the Western United States. *Journal of Climate* 19:4545-4559.

Lund, J. R., E. Hanak, W. E. Fleenor, W. A. Bennett, R. E. Howitt, J. F. Mount, and P. B. Moyle. 2010. *Comparing Futures for the Sacramento-San Joaquin Delta*. University of California Press: Berkeley, CA. p. 231.

Miller, R. L., M. Fram, R. Fujii, and G. Wheeler. 2008. Subsidence reversal in a re-established wetland in the Sacramento-San Joaquin Delta, California, USA. *San Francisco Estuary and Watershed Science* 6.

NRC (National Research Council of the National Academies). 2004. *Improving the Use of "Best Scientific Information Available" Standard in Fisheries Management.* The National Academies Press, Washington, D.C. Site accessed July 2010. http://www.nap.edu/catalog.php?record_id=11045#toc.

NRC (National Research Council of the National Academies). 2012. *Sustainable Water and Environmental Management in the California Bay-Delta*. The National Academies Press, Washington D.C. http://www.nap.edu/catalog.php?record_id=13394.

Sommer, T., C. Armor, R. Baxter, R. Breuer, L. Brown, M. Chotkowski, S. Culberson, F. Feyrer, M. Gingras, B. Herbold, W. Kimmerer, A. Mueller-Solger, M. Nobriga, and K. Souza. 2007. The collapse of pelagic fishes in the Upper San Francisco Estuary. *Fisheries* 32:270-277.

Stanford, J. A., and G. C. Poole. 1996. A protocol for ecosystem management. *Ecological Applications* 6:741-744.

Sullivan, P. J., J. M. Acheson, P. L. Angermeier, T. Faast, J. Flemma, C. M. Jones, E. E. Knudsen, T. J. Minello, D. H. Secor, R. Wunderlich, and B. A. Zanetell. 2006. *Defining and Implementing Best Available Science for Fisheries and Environmental Science, Policy, and Management*. American Fisheries Society, Bethesda, Maryland, and Estuarine Research Federation, Port Republic, Maryland. Site accessed July 2010. http://www.fisheries.org/afs/docs/policy_science.pdf.

Weston, D. P., R. J. Holmes, J. You, and M. J. Lydy. 2005. Aquatic toxicity due to residential use of pyrethroid insecticides. *Environmental Science and Technology* 39: 9778–9784.

Weston, D. P., and M. J. Lydy. 2010. Urban and agricultural sources of pyrethroid insecticides to the Sacramento–San Joaquin Delta of California. *Environmental Science and Technology* 44: 1833-1840.

Williams, B. K., R. C. Szaro, and C. D. Shapiro. 2009. *Adaptive Management: The U.S. Department of the Interior Technical Guide*. Adaptive Management Working Group, U.S. Department of the Interior, Washington, D.C. p. 72.

Winder, M., A. D. Jassby, and R. Mac Nally. 2011. Synergies between climate anomalies and hydrological modifications facilitate estuarine biotic invasions. *Ecology Letters*: DOI: 10.1111/j.1461-0248.2011.01635.x.

Photo Credits

Chapter divider *(clockwise from top left)***:** California Department of Water Resources, ZoArt Photography, California Department of Water Resources, and California Department of Water Resources.

Page 31: ZoArt Photography

Page 45: Delta Stewardship Council

This page intentionally left blank.

CHAPTER 3

A More Reliable Water Supply for California

ABOUT THIS CHAPTER

This chapter provides an overview of California's water supply, where it comes from, and how it is used. It also describes California's water policy foundations, including federal, State of California (State), and local policies, laws, and programs, and the need for continued improvements in local water planning, management, and information. It explains the special role of the Sacramento-San Joaquin Delta (Delta) in California's water, including its history, conflicts and challenges, and necessary investments and changes to achieve flexibility, improve resiliency, and increase water supply reliability.

As a starting point for this Delta Plan, four core water strategies must be implemented throughout the state to achieve the coequal goal of providing a more reliable water supply for California:

- Increase water conservation and expand local and regional supplies
- Improve groundwater management
- Improve conveyance and expand storage
- Improve water management information

These core strategies form the basis of the 2 policies and 19 recommendations found at the end of the chapter.

RELEVANT LEGISLATION

The Sacramento-San Joaquin Delta Reform Act of 2009 declares State policy for California's water resources and the Delta (Water Code section 85054):

> *"Coequal goals" means the two goals of providing a more reliable water supply for California and protecting, restoring, and enhancing the Delta ecosystem. The coequal goals shall be achieved in a manner that protects and enhances the unique cultural, recreational, natural resource, and agricultural values of the Delta as an evolving place.*

The Legislature declares the following objectives inherent in the coequal goals for management of the Delta (Water Code section 85020):

> *(a) Manage the Delta's water and environmental resources and the water resources of the State over the long term.*
>
> *(d) Promote statewide water conservation, water use efficiency, and sustainable water use.*
>
> *(f) Improve the water conveyance system and expand statewide water storage.*

The Legislature declared that:

> *85004(b) Providing a more reliable water supply for the state involves implementation of water use efficiency and conservation projects, wastewater reclamation projects, desalination, and new and improved infrastructure, including water storage and Delta conveyance facilities.*

Reduced reliance on the Delta for water supplies is established as State policy, along with an associated mandate for regional self-reliance (Water Code section 85021):

> *The policy of the State of California is to reduce reliance on the Delta in meeting California's future water supply needs through a statewide strategy of investing in improved regional supplies, conservation, and water use efficiency. Each region that depends on water from the Delta watershed shall improve its regional self-reliance for water through investment in water use efficiency, water recycling, advanced water technologies, local and regional water supply projects, and improved regional coordination of local and regional water supply efforts.*

Water Code sections 85302, 85303, 85304, and 85211 provide direction on measures that must be included in the Delta Plan to meet the statewide water supply policy goals and objectives, and ultimately the coequal goal of increased water supply reliability:

> *85302(d) The Delta Plan shall include measures to promote a more reliable water supply that address all of the following:*
>
> > *(1) Meeting the needs for reasonable and beneficial uses of water.*
> >
> > *(2) Sustaining the economic vitality of the State.*
> >
> > *(3) Improving water quality to protect human health and the environment.*
>
> *85303 The Delta Plan shall promote statewide water conservation, water use efficiency, and sustainable use of water.*
>
> *85304 The Delta Plan shall promote options for new and improved infrastructure relating to the water conveyance in the Delta, storage systems, and for the operation of both to achieve the coequal goals.*
>
> *85211 The Delta Plan shall include performance measurements that will enable the council to track progress in meeting the objectives of the Delta Plan. The performance measurements shall include, but need not be limited to, quantitative or otherwise measurable assessments of the status and trends…*
>
> > *(b) The reliability of California water supply imported from the Sacramento River or the San Joaquin River watershed.*

The longstanding constitutional principle of reasonable use and the Public Trust Doctrine form the foundation of California's water management policy, and are particularly applicable to the Delta watershed and to the others areas that use Delta water as the basis for resolving water conflicts (Water Code section 85023). The constitutional principle is defined in Section 2 of Article X of the California Constitution as:

The right to water or to the use or flow of water in or from any natural stream or water course in this State is and shall be limited to such water as shall be reasonably required for the beneficial use to be served, and such right does not and shall not extend to the waste or unreasonable use or unreasonable method of use or unreasonable method of diversion of water.

Water Code sections 85031 and 85032 provide clarification that existing water rights, procedures, or laws are not affected:

85031(a) This division does not diminish, impair, or otherwise affect in any manner whatsoever any area of origin, watershed of origin, county of origin, or any other water rights protections, including, but not limited to, rights to water appropriated prior to December 19, 1914, provided under the law. This division does not limit or otherwise affect the application of Article 1.7 (commencing with Section 1215) of Chapter 1 of Part 2 of Division 2, Sections 10505, 10505.5, 11128, 11460, 11461, 11462, and 11463, and Sections 12200 to 12220, inclusive.

(b) For the purposes of this division, an area that utilizes water that has been diverted and conveyed from the Sacramento River hydrologic region, for use outside the Sacramento River hydrologic region or the Delta, shall not be deemed to be immediately adjacent thereto or capable of being conveniently supplied with water therefrom by virtue or on account of the diversion and conveyance of that water through facilities that may be constructed for that purpose after January 1, 2010.

(c) Nothing in this division supersedes, limits, or otherwise modifies the applicability of Chapter 10 (commencing with Section 1700) of Part 2 of Division 2, including petitions related to any new conveyance constructed or operated in accordance with Chapter 2 (commencing with Section 85320) of Part 4 of Division 35.

(d) Unless otherwise expressly provided, nothing in this division supersedes, reduces, or otherwise affects existing legal protections, both procedural and substantive, relating to the state board's regulation of diversion and use of water, including, but not limited to, water right priorities, the protection provided to municipal interests by Sections 106 and 106.5, and changes in water rights. Nothing in this division expands or otherwise alters the board's existing authority to regulate the diversion and use of water or the courts' existing concurrent jurisdiction over California water rights.

85032 This division does not affect any of the following:

(a) The Natural Community Conservation Planning Act (Chapter 10 (commencing with Section 2800) of Division 3 of the Fish and Game Code).

(b) The California Endangered Species Act (Chapter 1.5 (commencing with Section 2050) of Division 3 of the Fish and Game Code).

(c) The Fish and Game Code.

(d) The Porter-Cologne Water Quality Control Act (Division 7 (commencing with Section 13000).

(e) Chapter 8 (commencing with Section 12930) of Part 6 of Division 6.

(f) The California Environmental Quality Act (Division 13 (commencing with Section 21000) of the Public Resources Code).

(g) Section 1702.

(h) The application of the public trust doctrine.

(i) Any water right.

(j) The liability of the state for flood protection in the Delta or its watershed.

CHAPTER 3

A More Reliable Water Supply for California

In California, the conflicts over water are legendary. The connotations of wealth and power associated with control over water were captured in dramatic fashion in the 1974 film *Chinatown*. A decade later, Marc Reisner's bestselling nonfiction book, *Cadillac Desert*, described vast, arid California land tracts turned to lush, productive fields through the modern magic of water diversion and irrigation. California is known for many things: the urban, cultural giant that is Los Angeles; the great Central Valley, breadbasket to the world; cutting-edge technological advances hailing from Silicon Valley; and the fertile human-made islands of the Delta. The thread that ties these places together is a supply of fresh water from the Sacramento-San Joaquin watershed. Similarly, dozens of fish species—some of them threatened by extinction—and a diverse palette of flora and fauna also depend on this water. As described in Chapter 1, at the heart of California's water troubles are scarcity of supply and competing uses—in particular, conflict with the water needs of the ecosystem. This dynamic of conflict characterizes the essential debate over management of the Delta.

Building on the foundations of California water policy, the Delta Reform Act established the goal of providing "a more reliable water supply for California." This is coequal with the goal of "protecting, restoring, and enhancing the Delta ecosystem." Both must be accomplished while protecting and enhancing the unique values of the Delta as an evolving place. (See sidebar, What Does It Mean to Achieve the Goal of Providing a More Reliable Water Supply for California?)

The Delta Reform Act recognizes that the "Delta watershed and California's water infrastructure are in crisis and existing Delta policies are not sustainable" (Water Code section 85001(a)). The economies of major regions of the state are reliant upon the ability to use water within the Delta watershed or on water imported from the Delta watershed. Yet, the long-term impacts of these diversions, on the Delta and its watershed, in combination with many other factors, are causing native fisheries to decline. In recent years, the populations of salmon and several other fish species have reached their lowest numbers in recorded history, and many of California's salmon runs are now listed as endangered by the State or federal government. The courts have responded by imposing constraints, particularly in dry years, on water diversions through the Delta. As a result, water deliveries—particularly those that come from the State Water Project (SWP) and the federal Central Valley Project (CVP)—have become increasingly unpredictable.

The Delta Reform Act mandates many strategies that the Delta Plan must address to improve water supply reliability for California:[1]

- Promote, implement, and invest in water efficiency and conservation
- Implement and invest in wastewater reclamation and water recycling
- Increase and invest in desalination and advanced water treatment technologies
- Promote and implement options for improved water conveyance

[1] See Water Code sections 85004(b), 85020(d) and (f), 85021, 85023, 85302(d), 85303, and 85304.

- Expand and invest in storage
- Improve water quality to protect human health and the environment
- Invest in local and regional water supply projects and coordination
- Prohibit waste and unreasonable use, consistent with Article X, Section 2 of the California Constitution, and protect public trust resources consistent with the Public Trust Doctrine

California's precipitation is extremely variable, and both droughts and floods are not uncommon, even occurring in back-to-back years. Therefore, the State must adapt its water infrastructure and operations in the Delta to make better use of the greater volumes of water that are and, in the future, will continue to be available during wet years, and to take less water during dry years when conflicts with the Delta ecosystem and in-Delta water quality are at their greatest. Concurrently, the development and careful management of local water resources hold tremendous potential for improving water reliability and must be a priority for California.

Management of any natural resource is a continual balancing act. Establishment of the coequal goals provides policy priorities when it comes to managing water, but continuing disputes are inevitable. Given that water in California is scarce, actions that occur in one corner of the state can have ripple effects hundreds of miles away. Levee failures in the Delta may interrupt water supplies to industry in San Diego. Conversely, the way Southern California regions manage their water may affect California's water-dependent ecosystems. The management of a salinity regime to benefit the environment has implications for in-Delta water users. Upstream water use can affect the quality and quantity of water for all downstream users—urban, agricultural, or environmental. Decades-old decisions to drain swamps, build intrastate water projects, and mine gold have left legacy imprints on California's water and ecosystem management.

Although exports from the Delta account for only a fraction of California's water supplies, the Delta is of widespread importance given its geographic location and influential role in ecosystem dynamics. Those who live in the Delta watershed are concerned about how management actions in the Delta may affect them; those who live in the Delta are keenly aware of others' interest in their backyard; and those who rely fully or partially on Delta exports, in some cases located hundreds of miles from the Delta itself, fear the impacts of reduced water supply reliability on their local economies and standard of living.

The broad influence of the Delta is precisely why the Delta crisis cannot be resolved by taking actions in the Delta alone. The Delta Reform Act establishes a new policy for California of reducing "reliance on the Delta in meeting California's future water supply needs" (Water Code section 85021). Reduced reliance is to be achieved through a statewide strategy of investing in improved local and regional supplies, conservation, and water use efficiency so that "each region that depends on water from the Delta watershed shall improve its regional self-reliance." The State's water planning document, the *California Water Plan – Update 2009*, estimates that California could reduce water demand and increase water supply in the range of 5 to 10 million acre-feet (MAF) by 2030 just through the implementation of existing strategies and technology (DWR 2009). This amount of water is more than enough to meet the projected water demands of California's growing population through 2050. An integrated approach that includes increased water efficiency, local and regional diversification of water supplies, reduced reliance on water from the Delta, improved regional self-reliance, and concurrent improvements to storage and Delta infrastructure will build the resiliency and reliability of California's water supply.

WHAT DOES IT MEAN TO ACHIEVE THE GOAL OF PROVIDING A MORE RELIABLE WATER SUPPLY FOR CALIFORNIA?

Achieving the coequal goal of providing a more reliable water supply for California means better matching the state's demands for reasonable and beneficial uses of water to the available water supply.

- This will be done by promoting, improving, investing in, and implementing projects and programs that improve the resiliency of the state's water systems, increase water efficiency and conservation, increase water recycling and use of advanced water technologies, improve groundwater management, expand storage, and improve Delta conveyance and operations. The evaluation of progress toward improving reliability will take into account the inherent variability in water demands and supplies across California.

Regions that use water from the Delta watershed will reduce their reliance on this water for reasonable and beneficial uses, and improve regional self-reliance, consistent with existing water rights and the State's area of origin statutes and Reasonable Use and Public Trust Doctrines.

- This will be done by improving, investing in, and implementing local projects and programs that increase water conservation and efficiency, increase water recycling and use of advanced water technologies, expand storage, improve groundwater management, and enhance regional coordination of local and regional water supply development efforts.

Water exported from the Delta will more closely match water supplies available to be exported, based on water year type and consistent with the coequal goal of protecting, restoring, and enhancing the Delta ecosystem.

- This will be done by improving conveyance in the Delta and expanding groundwater and surface storage both north and south of the Delta to optimize diversions in wet years when more water is available and conflicts with the ecosystem less likely, and limit diversions in dry years when conflicts with the ecosystem are more likely. Delta water that is stored in wet years will be available for water users during dry years, when the limited amount of available water must remain in the Delta, making water deliveries more predictable and reliable. In addition, these improvements will decrease the vulnerability of Delta water supplies to disruption by natural disasters, such as earthquakes, floods, and levee failures.

DP-142

Accordingly, the Delta Stewardship Council (Council) envisions a future in which California has achieved the coequal goal of improved water supply reliability. In the future:

- California's water resources will be better managed, consistent with the State's Reasonable Use and Public Trust Doctrines.
- Improved efficiency and a greater diversity of sources will make more water available to meet the state's demands.
- Groundwater resources will be sustainably managed, and critical overdraft in groundwater basins will have been eliminated.
- Water suppliers in regions that use water from the Delta watershed will have reduced their reliance on this water and improved their regional self-reliance. California will be better prepared to meet the challenges of climate change and catastrophic events that may affect future water deliveries.

In the future, water exports from the Delta will more closely match water supplies available to be exported, consistent with California's variable hydrology and the coequal goal of protecting, restoring, and enhancing the Delta ecosystem. Conveyance facilities in the Delta will be improved, and additional groundwater and surface storage, both north and south of the Delta, will help optimize diversions in wet years when more water is available and conflicts with the ecosystem are less likely, and limit diversions in dry years when conflicts with the ecosystem are more likely. These patterns of Delta exports will be consistent with more natural flow patterns in the Delta, which will aid native species and reduce regulatory uncertainty. At the same time, deliveries of Delta water will be more predictable due to use of storage to deliver wet-year water that is exported and stored for future use. Flexibility of export operations will be enhanced through implementation of local and regional water efficiency, improved conveyance to reduce conflicts with the ecosystem, and water supply projects that reduce pressure on the Delta and reliance on these deliveries.

California's Water Supply Picture

California's water supply picture makes it unlike any other state in the nation. Geography, hydrology, circumstance, and governance have shaped the political landscape of California water in a manner that has both intrigued and frustrated people for decades. Engineering alterations have enabled urban metropolises to thrive—and sprawl—and expansive agricultural regions with global influence to flourish with supplemental water, imported in some cases from hundreds of miles away and across county and even state boundaries. A complex and sometimes conflicting system of laws and policies means that in dry years, frequent in California, a given water district might have surplus supplies with which to grow lettuce or alfalfa, while a district next door battles drought conditions and the associated economic and environmental impacts. A growing awareness of how past water management practices have led to current environmental conflicts and overall competition for water supplies, combined with the knowledge that past climate patterns are not necessarily indicative of the next century's hydrograph, are shaping how California plans for its water future (see Figure 3-1).

This section provides an overview of where California's water comes from and how it is used, the state's vast water supply infrastructure system, and the implications of climate change on California's water supplies.

Sources of California's Water Supply

Variability and uncertainty are the dominant characteristics of California's water resources. Precipitation is the primary source of California's water supply. However, this precipitation varies greatly from year to year, as well as by season and where it falls geographically in the state, which makes management of the state's water resources complex and challenging. Groundwater, which is often connected to surface supplies, contributes to a significant portion of California's water use, on average supplying 8 MAF (20 percent) of California's urban and agricultural uses; but in some areas, this figure is considerably higher and can be as much as 60 to 80 percent of a region's water supply (DWR 2009). Groundwater, and implications for its overuse, is discussed in greater detail later in this chapter.

The total amount of precipitation in an average year provides California with about 200 MAF of surface water falling as either rain or snow (DWR 2009).[2] The actual volume of water the state receives each year varies dramatically depending on whether the year is dry or wet. California may receive less than 100 MAF of water during a dry year and more than 300 MAF in a wet year (Western Regional Climate Center 2011a).

The term "average water year" in California is useful for explanatory purposes, but can be misleading as a measurement for planning. In fact, California experiences the most unpredictable pattern of precipitation in the nation, with the bulk of its annual water falling within just 5 to 15 days (Dettinger et al. 2011). This means that in years when fewer storms pass over California, the state faces the problem of too little water; conversely, a few extra storms may result in flooding. For example, between 2005 and 2008, Los Angeles experienced both its driest and wettest years on record (California Natural Resources Agency 2008). The historical record shows that California has frequently experienced long multiyear droughts, as well as extremely wet years that coincide with substantial flooding and consequent risk to people and property (Hanak et al. 2011).

[2] Includes up to 10 MAF of precipitation that occurs in Oregon, Mexico, and the Colorado River and is imported into California.

How California's Water Is Used

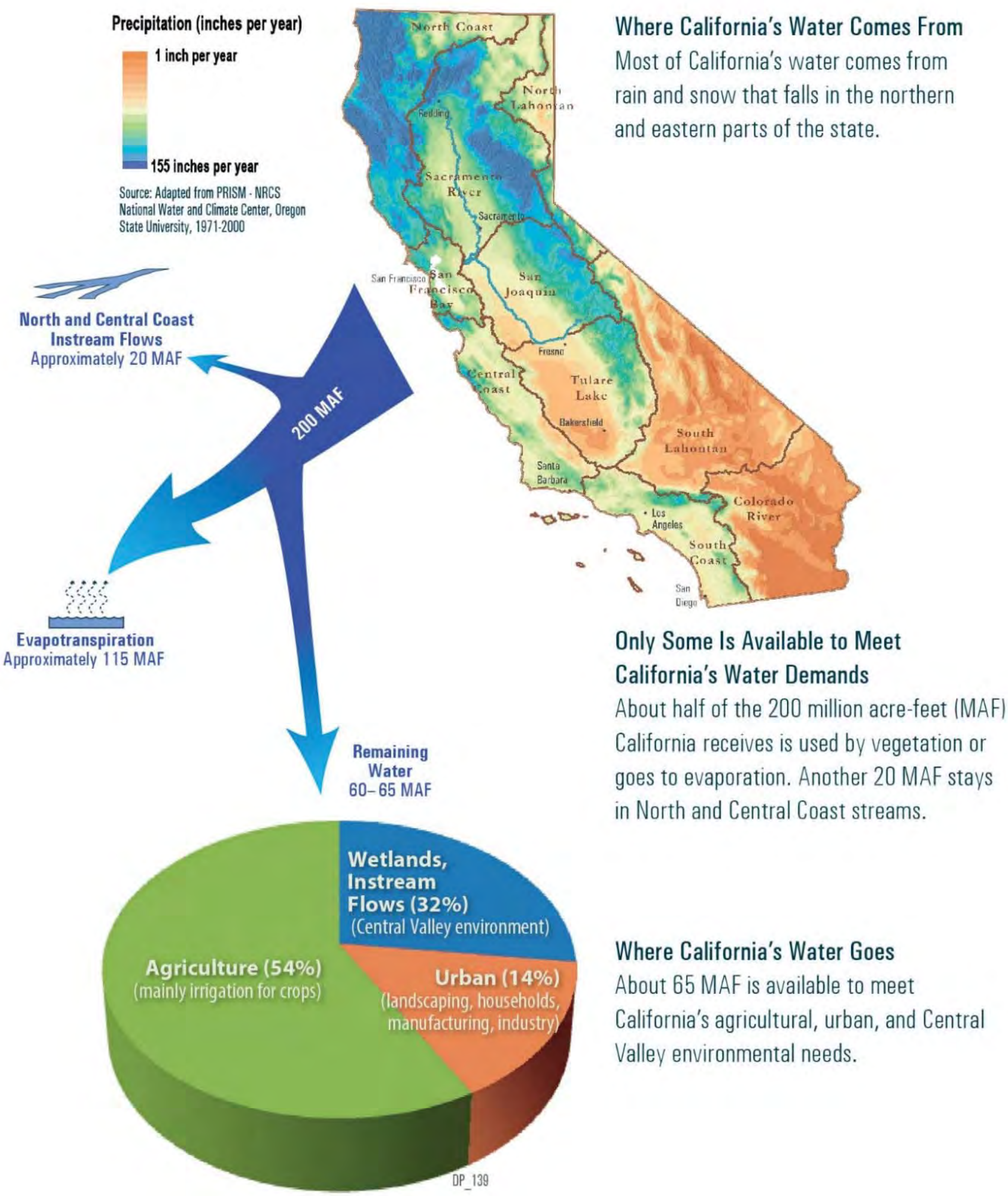


Figure 3-1 *Sources: Adapted from DWR 2009, USGS 2010*

Most of California's precipitation occurs between November and April, yet most of the state's agricultural and urban water demand is in the hot, dry months of summer and early fall, creating a management challenge. In addition, most of the precipitation falls in the mountains in the middle to northern half of the state, far from major population and agricultural centers. In some years, the far north of the state can receive 100 inches or more of precipitation while the southernmost regions receive only a few inches (Western Regional Climate Center 2011b). These basic characteristics of precipitation in California—seasonal timing and geography—and their fundamental disconnect with where and when Californians demand water provide the basic explanation for why water in California is such a complicated and controversial matter.

How California's Water Is Used

The amount of water available to meet agricultural, urban, and ecosystem water demands starts with the state's annual precipitation. On average, about half of this water evaporates; is used by surface vegetation for transpiration; or flows to deep subsurface areas, saline sinks, or the ocean (DWR 2009). The rest of this water—known as "dedicated water"[3]—is used to supply urban municipal and industrial uses, agricultural irrigation, water for ecosystem protection and restoration, and for storage in surface and groundwater reservoirs (DWR 2009).

Patterns of how and when water is used in the state vary with the type of water year. In fact, although best available estimates are included in this Delta Plan, state water managers often work with limited or incomplete information related to water use. The California Department of Water Resources (DWR) uses five water year–type classifications for planning and management purposes: wet, above normal, below normal, dry, and critically dry. In wet years, due to plentiful local rainfall, agricultural and urban landscape irrigation water demands are generally lower. Water demands are usually highest in years of reduced rainfall and because local supplies are low (DWR 2009). Ironically, agricultural and urban water demands may be lower during critically dry years because of short-term water use reduction actions, such as rationing or cropland fallowing to cope with water shortages.

In an average water year, this dedicated water totals approximately 80 to 85 MAF.[4] Again, the fluctuations between wet and dry years can be extreme, with wet years providing more than 95 MAF and critically dry years producing less than 65 MAF of available supply (LAO 2008, DWR 2009, USGS 2010).

However, not all of the 80 to 85 MAF is available to meet water demands within the Central Valley, Bay Area, and Southern California. In the late 1970s, the California Legislature secured State and federal protection of California's North Coast rivers and, in doing so, precluded major diversions from these rivers, including parts of the Trinity, Scott, Salmon, Eel, and Klamath rivers. Water from these rivers is now largely mandated to the environment by law, with the exception of diversions from the Trinity River to the Sacramento River for CVP supplies that are limited by federal law (Hanak et al. 2011). As a result, in an average year, approximately 20 MAF (out of the available supply of 80 to 85 MAF) are reserved for Wild and Scenic Rivers and other instream flow requirements in the North Coast and San Francisco Bay regions and some Central Coast and South Coast areas. Most of this water falls outside the Delta watershed. Although original State water plans and State and federal water contracts envisioned its capture and conveyance, permanent legal protections now prohibit it. (See the CVP and SWP Water Delivery Challenges section.)

[3] DWR uses the terms "dedicated" and "developed" interchangeably in their publications. DWR identifies California's average annual dedicated water supply as 85 MAF.

[4] All statewide average water use values were calculated using information in Volume 5 DWR Water Plan 2009 (including average values for years 1998 through 2005) and results from CALSIM II model runs prepared for DWR State Water Project Reliability Studies (DWR 2010b, DWR 2011c).

This means that the remaining water supply (of 60 to 65 MAF in an average year) goes to meet agricultural and urban demands and Central Valley environmental needs.[5,6] In an average year, irrigated agriculture uses approximately 34 MAF (54 percent) of this water, urban areas use about 9 MAF (14 percent), and 20 MAF (32 percent) is mandated to meet instream flow requirements, including State Water Resources Control Board (SWRCB) Delta water quality requirements and Central Valley wildlife refuge commitments (DWR 2009).

Accounting for how much water each sector actually uses is complicated because water may be reused several times for different purposes or it may be taken from surface or groundwater storage held from previous years.[7] The lack of consistent and accurate estimates of statewide water use is a significant challenge that has important implications for improved water management in California.

Future population and economic growth is expected to result in increased water demand. Today, California's water supply supports a population of 36.5 million people, an economy of $1.9 trillion, and diverse natural resources (LAO 2011). The largest economic sectors in the state are trade, transportation, and financial services, with agricultural services contributing about $38 billion (2 percent). Projections by the California Department of Finance in 2010 forecast that the population may grow to 60 million people by 2050, but the rate of growth is slowing and could be much lower.[8] As more development occurs, water use will continue to shift away from agricultural toward urban uses (DWR 2005, DWR 2009, LAO 2008, Hanak et al. 2011). At the same time, increasing water needs for ecosystem protection will likely exacerbate conflicts with agricultural and urban water demands.

California's Water Supply Infrastructure

To provide more reliable water supplies despite the state's hydrologic variability and diverse geography, and also to manage floods during wet years, State, federal, and local agencies have built a vast, interconnected infrastructure system throughout California (see Figure 3-2). The Delta, because of its geographic location and role in conveying water supplies, is often described as the "linchpin" of California's water infrastructure. Rivers and dredged channels act as conveyance canals, and pumping plants provide the momentum to move stored water to areas south. California's overall system includes a range of surface reservoirs, aqueducts, pumping plants, operable gates, groundwater wells, and water treatment facilities constructed over the last hundred plus years.

5 Data are from 2000, which DWR categorized as an "average" rainfall year for the state.

6 The "remaining water" of approximately 60 to 65 MAF, (62.4 MAF for purposes of percentage calculations) is referred to throughout this chapter as "total water use," unless otherwise specified. Total water use includes urban, agricultural, and Central Valley environmental uses such as instream flow requirements and non-CVP-managed wetlands.

7 For example, water that is dedicated to instream flows often becomes available for downstream diversion to agricultural and urban uses. Some portion of the water that is used for agricultural irrigation or drinking water is returned to the ecosystem through agricultural tailwater releases, infiltration of irrigation water into groundwater, and discharges from sewage treatment plants. The State does not have a system for documenting these multiple uses.

8 Growth projections by the California Department of Finance are regularly revised and over the past 2 decades reflect a trend toward slower expected growth for the state. Between 1993 and 2004, the California Department of Finance's population projections for 2040 declined by 12 million people, from 62 million to 50 million.

Moving and Storing California's Water

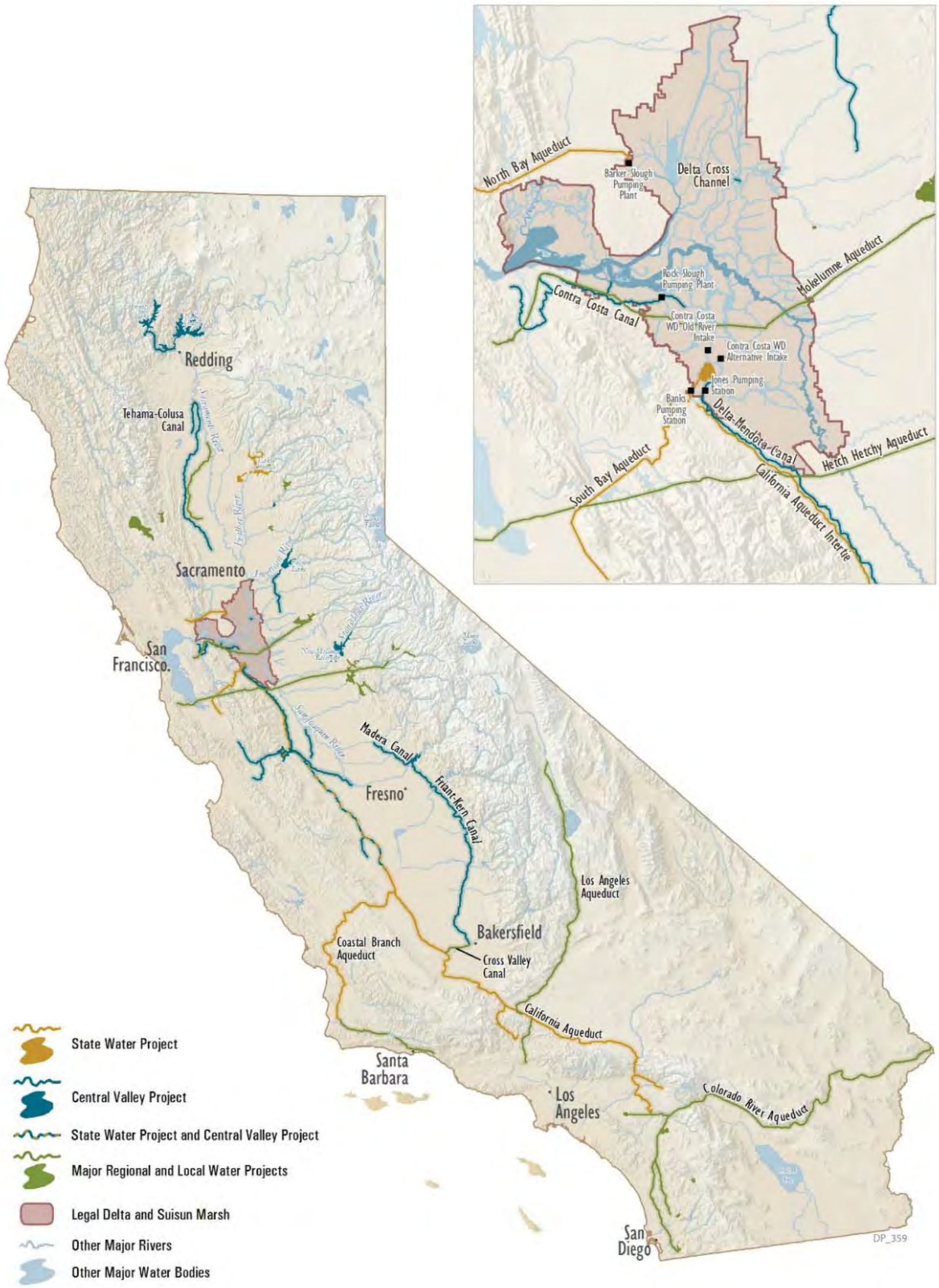


Figure 3-2

Large State, federal, and local dams and canal systems play an important role in storing and conveying water throughout California to meet a variety of urban and agricultural water demands.

Source: Adapted from DWR 2009

On average, local and regional water supplies account for 52 MAF (84 percent) of the state's total water use. Of the 52 MAF, about 44 MAF (84 percent) of the water supply comes from local surface water storage and deliveries, and includes sources such as the Santa Ana, Los Angeles, and Ventura river watersheds in Southern California; local diversions from the Sacramento and San Joaquin rivers; and stream drainages in the central coastal areas. In addition, groundwater supplies about 8 MAF (13 percent) of the state's total water use in average years (20 percent of urban and agricultural water use), and during droughts, can provide up to 60 percent or more for specific regions (DWR 2009). A small but rapidly growing percentage of local water comes from recycled water and water reuse projects.

Supplemental water supplies are conveyed from wetter regions of California, primarily through diversions of runoff from the great Sierra Nevada mountain range and some water from the Trinity River in the north state. In most regions, these imported water supplies augment local and regional sources, especially in dry years and dry seasons. On average, approximately 10.1 MAF (16 percent) of the state's total water use comes through a combination of major conveyance and storage facilities from water sources within California and from other states, with the SWP and CVP making up the majority of these imports (5.1 MAF, about 8 percent), and Hetch Hetchy (0.2 MAF), Mokelumne (0.3 MAF), and the Los Angeles Aqueduct (0.2 MAF) comprising the remaining in-state imports. A significant portion of the state's water supplies are imported from outside California, primarily from the Colorado River (4.3 MAF) through the Colorado River Aqueduct, which serves agricultural and urban demand in Southern California.

The network of infrastructure to store and convey water in California is impressive by modern standards and compared to other states. The state's single largest "reservoir" is the Sierra Nevada snowpack, which holds approximately 15 MAF per year on average (DWR 2009). However, for comparison, local, State, and federal agencies in California have constructed more than 1,200 major reservoirs with a combined storage capacity of 43 MAF, about half the average annual runoff for the entire state (Hanak et al. 2011, DWR 2011a).

Most of California's largest surface storage reservoirs are owned and operated by the federal government and total approximately 17 MAF of storage capacity. The largest federal facility, part of the CVP, is Shasta Lake, which holds 4.5 MAF. The State's single largest storage facility and keystone feature of the SWP, Lake Oroville Dam on the Feather River, has a capacity of 3.5 MAF (LAO 2008). Operating with other reservoirs as a system, these multibenefit facilities reduce the potential for floods at the same time that they make water available for seasonal water agricultural and urban demand, particularly in the summer and fall. They also generate clean electricity. Although these storage facilities provide many benefits, they have also significantly altered the natural ecology of these rivers. Dams and their associated facilities can present barriers to migrating fish and reduce or eliminate downstream gravel and sediment replenishment to the detriment of native species such as salmon. Moreover, reservoir operations have significantly modified the amount and timing of instream flows, as well as water temperature, further contributing to the decline of the state's native fish and ecological resources.

Looking to the future, fewer high-yielding surface storage sites are available in the state now because most of these areas have already been developed (NRC 2012). However, there are significant opportunities throughout California to expand groundwater storage and to reoperate surface storage in conjunction with groundwater storage (also known as conjunctive management or groundwater banking) and other programs to maximize the water supply and environmental benefits of these systems.

Climate Change Complicates Management of California's Water

With climate change, the state's water supply will become even more erratic. Weather patterns are expected to become more extreme with long, multiyear droughts becoming more frequent as well as extremely wet years. Since 1906, California has seen "dry or critically dry" years one-third of the time. This trend is increasing (California Data Exchange Center 2011).

By 2050, temperature increases of 1 to 3 degrees Celsius are expected to cause more winter precipitation to fall as rain, as opposed to snow, and to reduce the Sierra Nevada snowpack (the source of much of California's runoff) by 25 to 40 percent (DWR 2010d). Runoff patterns will shift, leading to greater cool-season runoff and decreased warm-season runoff (Reclamation 2011a). The pattern of spring runoff is also expected to change, with a more rapid spring snowmelt leading to a shorter, more intense spring period of river flow and freshwater discharge accompanied by higher flooding risks (Knowles and Cayan 2004, Knowles et al. 2006, Null et al. 2010, Willis et al. 2011). Because the Delta watershed provides a portion of the water supply for approximately 27 million Californians and irrigates millions of acres of farmland, rising sea levels leading to increased salinity intrusion, along with changes in the form of precipitation and timing of snowmelt, will profoundly alter the way water is managed in California.

Specifically, an anticipated shift in runoff patterns will present a management challenge to existing reservoir operations, with large runoff events increasingly putting pressure on reservoirs managed for multiple benefits, including flood control. Reduced natural water storage in the form of snowpack will diminish statewide carryover storage capacity, making the state increasingly vulnerable during prolonged dry periods and negatively affecting water supply reliability.

Sea level rise, as much as 55 inches by 2100 (OPC 2011), will result in high salinity levels in the Delta interior, which will impair water quality for agricultural and municipal uses, and change habitat for fish species. Maintaining freshwater conditions in the Delta could require unanticipated releases of water from storage, which will reduce available water supplies for fish. Rising seas also will dramatically increase the risk of catastrophic interruption of water exports as a result of levee failure and flood events, particularly in the interior Delta where substantial subsidence has already occurred. Warmer temperatures throughout the state will cause higher evaporation rates, particularly during the hot summer and early fall months, contributing to reduced streamflows, drier soils, reduced groundwater infiltration, higher losses of water from surface reservoirs, increased urban and agricultural demand for irrigation water, and more water needed for ecosystem protection (California Natural Resources Agency 2008).

The precise local impacts of climate change on regional water resources remain less certain. Many communities in the state already experience water shortages during droughts (California Environmental Protection Agency 2006, LAO 2009). Improved modeling, especially downscaling of global climate change information to regional and local levels, will help communities to evaluate the extent of their vulnerability and to develop water management strategies that will increase the resilience of their water supply systems (USEPA and DWR 2011).

Foundations of Water Policy in California

Over the past 160 years, the California water rights system has evolved into a complex mix of public and private rights and contractual obligations that were intended to create more certainty about how water is to be allocated among urban, agricultural, and environmental uses during droughts, catastrophic interruptions in water supplies, and other times of scarcity. (See sidebar, California's Complex Water Rights System.) Yet some of these rights and obligations conflict, and now, in many years, there is insufficient water in California to support them all.

California's legal system recognizes limitations on water rights based on the longstanding doctrines of Reasonable Use and Public Trust (NRC 2012). The Delta Reform Act reiterates that the principles of reasonable use and public trust "shall be the foundation of state water management policy" and that they are "particularly important and applicable to the Delta" (Water Code section 85023). The coequal goals of improving water supply reliability for the state and restoring the Delta cannot be achieved by actions in the Delta alone. Every region in California, along with the cities and farms that receive Delta water, will need to improve their management of the state's scarce water resources.

This section discusses the legal foundations for California water policy, explains the state's system of water rights, and describes new water policies and priorities, including reduced reliance on the Delta and improved regional self-reliance, established by the Delta Reform Act.

Reasonable Use and the Public Trust Doctrines

The Reasonable and Beneficial Use and Public Trust Doctrines, in combination with existing water rights and the State's area of origin statutes, have long been the legal and policy foundation for water management in California. The State's Reasonable and Beneficial Use Doctrine specifically limits all water rights and water use in California to "such water as shall be reasonably required for the beneficial use to be served, and such right does not and shall not extend to the waste or unreasonable use or unreasonable method of use or unreasonable method of diversion of water" (California Constitution, Article X, Section 2).

The SWRCB is the primary agency responsible for ensuring that water is not wasted and that the reasonable use standard is not violated. However, DWR also shares with them the duty to "take all appropriate proceedings and actions…to prevent waste, unreasonable use, unreasonable method of use, or unreasonable method of diversion in this state" (Water Code section 275). The SWRCB also is responsible for determining whether any water remains available in a stream or watershed for appropriation and whether the water is being fully used for "beneficial uses," consistent with State law that identifies the types of water uses that are permitted.[9] The State can review and modify existing water rights as well as consider approval of new permits and water rights to

reflect new conditions, including California statutes that require efficient water use and improved water management.

The Public Trust Doctrine provides the State with additional authority to reconsider past water allocation decisions in light of new information and changing water demands and social values, and to modify or revoke previously granted water rights if warranted. In a 1983 landmark legal decision, the California Supreme Court unanimously affirmed that the state's navigable lakes and streams are resources that are held in trust for the public and are to be protected for navigation, commerce, fishing, recreational, ecological, and other public values. The State "has an affirmative duty to take the public trust into account in the planning and allocation of water resources and to protect public trust uses whenever feasible" (*National Audubon Society v. Superior Court*, 33 Cal. 3d 419, 658 P.2d 709, 189 Cal. Rptr. 346, 1983 Cal.). This has significant implications for governance of water resources. In fact, both the Public Policy Institute of California and Appeals Court Associate Justice Ron Robie recently called for the establishment of a public trust advocate at the SWRCB to ensure that the State's duty to protect California's public trust resources is being performed adequately (Robie 2012, Hanak et al. 2011).

[9] Beneficial uses recognized in California include domestic, fire protection, fish and wildlife, industrial, irrigation, municipal, power production, recreation, and other uses (SWRCB 2010).

CALIFORNIA'S COMPLEX WATER RIGHTS SYSTEM

Whatever the type of water right that is held by an individual, business, or public agency, no one "owns" the water they use in California (Littleworth and Garner 2007). All water within the state is held in trust for the benefit of all the people of California (Water Code sections 102, 1201). Water rights holders have the right to "take and use water, but they do not own the water and cannot waste it" (*Central and West Basin Water Replenishment District v. Southern California Water Co.* (2003) 109 Cal. App. 4th 891, 905).

Riparian Rights – Landowners who own property that abuts a natural water course are entitled to make reasonable use of water on or flowing past their property. The water must be from a natural flow (not released stored water). Water cannot be stored under a riparian right and may only be used on property that is within the drainage of the water's source. If there is not enough water in a watershed to satisfy both riparian and appropriative rights, then riparian rights must be fulfilled first. In times of shortage, riparian right holders allocate the reduced water supply by sharing the shortage among the riparian users.

Appropriative Rights – An appropriative right is typically used when the prospective water user intends to use water on nonriparian land or the water user needs to store water for later use. Pre-1914, these rights were asserted in a manner similar to the filing of a mining claim; a water user filed a public notice of his or her intent to divert water and then diverted the water for a legally recognized beneficial use such as mining, irrigation, or drinking water. In times of shortage, appropriative right holders allocate the reduced water supply among themselves under a first in time, first in right priority system. Generally, water received through appropriative rights is more predictable than riparian rights, but appropriative rights can be lost through nonuse (because beneficial use is the basis for receiving the right), and shortages are allocated based on seniority (NRC 2012). California law recognizes water conservation as a "reasonable beneficial use" so that water efficiency improvements cannot be used as a reason to reduce appropriative rights held by a water user (Water Code section 1011(a)).

CVP and SWP Contractors – The Bureau of Reclamation and DWR hold appropriative water rights for the operation of the CVP and SWP, respectively. In many instances, these project rights are junior in priority to the rights held by water users in the Delta and within the Delta watershed. This means that during droughts and other periods of water shortages, the ability of the SWP and CVP to divert water from the Delta is limited by riparian owners and by more senior appropriative water rights.

Area of Origin Laws – Several statutes provide protections to areas within the Delta and the Delta watershed where the rivers originate (Littleworth and Garner 2007). Also known as "watershed protection" statutes, these laws provide the opportunity for water users in these areas to obtain water rights with a more senior priority than the SWP and CVP contractors so that local demands might be met before water becomes available for export.

Reasonable Use and Public Trust Doctrines – The SWRCB has the authority to review and modify existing water rights as well as approve new rights. This is an important principle because it enables the State to consider what is "reasonable" based on modern societal values, the need to protect other water users, protect the environment, and prevent the waste and unreasonable use of water. This authority derives in part, from the Public Trust Doctrine, under which the State has an ongoing duty to protect the navigable waters of the state for environmental protection, fishing, navigation, and commerce; and from the Reasonable Use Doctrine of the California Constitution, a provision mandating the reasonable and beneficial use of all waters in the state (Article X, Section 2).

DP-338

California's Water Rights System and Use Reporting

California's water rights system is of great legal significance. However, our water rights system does not and cannot guarantee a supply of water that exceeds what nature provides. Nor does any individual, business, industry, or agricultural enterprise "own" the water they use.

The amount of water used in California's stream systems is not fully known because water users under pre-1914 and riparian water rights have not been required, until recently, to submit annual reports accounting for their diversions. In 2009, the State adopted statewide water diversions reporting requirements (Water Code section 5100 et seq.); and in 2010, the SWRCB adopted regulations requiring online reporting of water use by all water rights holders, including all surface and groundwater users. In addition, there is limited information available to the State on consumptive use or the number of times that water is used within a stream system.

Discussed previously, the SWRCB has the authority to determine when a river or stream has been "over-appropriated," in other words, whether the amount of water available in a stream is less than the demands placed on that water. A right to use water represents potential diversions and uses. Actual water use in many rivers and streams is frequently far less than the total volume of asserted water rights. The difference between water rights and water received can be explained by restrictions or conditions in the permits/licenses, operation restrictions on the storage and transport facilities themselves, physical and economic limitations, non-consumptive uses such as hydroelectric power generation, and the use and reuse of water.

Understanding and reconciling the human demands for water to the supply available, while providing enough water to ensure desired and legally protected environmental and water quality goals, is a difficult process. This process is nonetheless essential to achievement of the coequal goals.

The Coequal Goals and Reducing Reliance on the Delta

In 2009, California further defined its water policy priorities as they relate to the Delta, including express recognition that the Delta crisis cannot be resolved by taking action in the Delta alone. Given the interconnected nature of the Delta with the water use patterns of large parts of Northern, Central, and Southern California, the new coequal goals of statewide water supply reliability and an improved, protected, and restored Delta ecosystem will fundamentally reshape California water management over the course of this century. Achieving these coequal goals is expected to be done, in significant part, through compliance with the Delta Reform Act's various mandates and goals relating to statewide water conservation, efficiency, and sustainable use, including the State's new policy to reduce reliance on the Delta and related mandate to improve regional self-reliance.

In particular, the Delta Reform Act mandates many statewide strategies that the Delta Plan must address to achieve the coequal goals, including water efficiency and conservation; wastewater reclamation and recycling; desalination and advanced water treatment technologies; improved water conveyance, surface, and groundwater storage; improved water quality; and implementation of local and regional water supply projects (Water Code sections 85004(b), 85020(d) and (f), 85021, 85023, 85303, and 85304). These measures help achieve the requirements of Water Code section 85021, which declares that the State's policy is "to reduce reliance on the delta in meeting California's future water supply needs through a statewide strategy of investing in improved regional supplies, conservation, and water use efficiency." That section also mandates that "[e]ach region that depends on water from the delta watershed shall improve its regional self-reliance for water through investment in water use efficiency, water recycling, advanced water technologies, local and regional water supply projects, and improved regional coordination of local and regional water supply efforts."

Consequently, to achieve the statewide water supply mandates and the coequal goal of statewide water supply reliability, regions located outside the Delta also must take actions outside the Delta to increase water efficiency and develop sustainable local and regional sources of water, which will contribute to improved water supply reliability.

Individual actions by water suppliers throughout the state will be vital to success in this regard. The implementation of programs and projects that result in a significant reduction in the amount of water used, or in the percentage of water used, from the Delta watershed (evaluated at the local, regional, and statewide levels) will be the foundational measures for assessing the State's progress in achieving these policies. The baseline for this evaluation will be existing water use and supplies, as documented in the most recently adopted urban and agricultural water management plans. (See Appendix G, Achieving Reduced Reliance on the Delta and Improved Regional Self-Reliance.)

It is important to recognize that reliance on water from the Delta and the Delta watershed varies throughout California, from region to region, and supplier to supplier. (See sidebar, Reliance on the Delta Varies by Region.) Some water suppliers have greater access to alternative water supplies or have a greater ability to implement a diverse range of water efficiency and water supply projects. Others, particularly in the upper watershed, may have a narrower range of options.

The key is that every supplier is doing its part and is taking appropriate action to contribute to the achievement of the coequal goals, including the State's policy of reduced reliance and associated mandate to improve regional self-reliance.

The Delta's Role in California's Water Supply

The Delta is the terminus for California's largest watershed, which encompasses the western slopes of the Sierra Nevada, the eastern slopes of the coastal range, and the valleys that lie between these ranges. Water in the Delta watershed starts as precipitation in the Sacramento River and San Joaquin River watersheds and, unless diverted or otherwise used, flushes San Francisco Bay and flows out to the ocean under the Golden Gate Bridge. Once again, this estuarine delta where California's two largest rivers meet is at the geographic and political center of water in California.

The CVP and the SWP rely on the Delta's artificial network of channels to convey water stored in upstream reservoirs to regions south of the Delta including the Bay Area, San Joaquin Valley, Tulare Lake Basin, Central Coast, and Southern California. (See sidebar, Reliance on the Delta Varies by Region, and Figure 3-3.)

Because of the Delta's central location, the water demands of many Californians are connected in some way to the Delta. Water diverted from the Delta watershed provides some portion of water supply for more than 27 million of the state's residents and approximately 3 million irrigated acres of farmland (DWR 2007a, DWR 2009, DWR 2011c, Reclamation 2011b). This water plays a critical role in helping to sustain a major portion of the state's $1.9 trillion economy.

This section provides an overview of water use and water infrastructure in the Delta watershed, followed by a description of water project operations in the Delta and the challenges and conflicts associated with these. The section concludes with a discussion of the importance of improving the flexibility of project operations, through improved conveyance, storage, and water management, in achieving the coequal goals.

Use of Water from the Delta Watershed

About half the state's runoff flows through the Delta watershed. Since the 1849 Gold Rush, communities throughout California have planned and constructed facilities to tap into this water to support economic development.

Many diversions in the Delta watershed occur in the upper watershed. On average, approximately 31 percent of the flow from the Delta watershed is diverted before it ever reaches the Delta (DWR 2011c). See Figure 4-5 in Chapter 4. These diversions are done through an extensive network of locally constructed dams, canals, and diversion structures that have been built over the past 160 years on nearly every stream and drainage within the Delta watershed (California Natural Resources Agency 2010). Some of the water diverted from Delta tributaries is returned to the tributaries through wastewater effluent and agricultural return flows, albeit at a degraded quality.

Water from these diversions sustains the economies of the residents, businesses, and growers who live in the areas where the water comes from—the "area of origin"—as well as the economies in the export areas. Some of these historical diversions occur through two large aqueduct and reservoir systems that were constructed early in the twentieth century to serve the growing water demands of San Francisco and East Bay Area communities. These facilities divert water before it reaches the Delta and convey it directly to reservoirs, treatment facilities, or customers in the Bay Area region. The Hetch Hetchy reservoir system on the Tuolumne River, and the Pardee and Camanche reservoirs system on the Mokelumne River account on average for approximately 0.5 MAF, or about 1.6 percent of the flow from the Delta watershed, of annual water deliveries from the Delta's upper watershed (DWR 2009).

RELIANCE ON THE DELTA VARIES BY REGION

Water exported from the Delta supplies about 8 percent of the state's total water use, and local and regional water supplies provide over 84 percent on average. However, reliance on water from the Delta watershed varies throughout California from region to region, supplier to supplier, and user to user.

For example, in the Sacramento and San Joaquin river watersheds, including water uses on the valley floor, foothills, mountain communities, and the Delta, the vast majority of the water supply comes from local sources: the rivers and reservoirs that flow into the Delta or from local groundwater resources that are replenished from runoff within the Delta watershed. Most of this water is used for irrigated agriculture, although increasing amounts are being shifted to drinking water and other municipal uses by the cities and towns that are growing in these regions. High-growth areas surrounding the Delta, including Fairfield, Sacramento, Stockton, and Tracy, are increasing urban water use and decreasing agricultural water use as the communities are developed.

Other regions, including the Tulare Lake region of the Central Valley, the San Francisco Bay Area, the South Coast, and the Central Coast, receive some portion of their water supply from diversions from the Delta's eastern tributaries or from water that is pumped from the Delta to supplement their limited local surface water and groundwater supplies. These exports vary by region and, for specific water users, the significance of these exports varies dramatically. For example:

- **Tulare Lake:** This region relies upon exports delivered through the Central Valley Project (CVP) and State Water Project (SWP) for 27 percent of its regional water supply, and most of this water use is for irrigated agriculture (on average 96 percent of CVP water deliveries and 89 percent of SWP deliveries). Kern County Water Agency, a water wholesaler, has the largest SWP import contract in the Tulare Lake Basin at nearly 1 million acre-feet (MAF) (DWR 2009).
- **San Francisco Bay Area:** This region's predominant water supply is from local sources (57 percent from surface and groundwater alone). However, diversions from the Delta's tributary streams provide up to 27 percent of this region's water, and CVP and SWP exports account for another 16 percent (DWR 2009). The reliance of the region's individual water suppliers on water from the Delta varies dramatically; the Marin Municipal Water District uses none (MMWD 2010), and the Zone 7 Water Agency in Alameda County receives as much as 82 percent of its water from SWP exports (Zone 7 2010).
- **Southern California:** This region is home to 50 percent of the state's population (with most in densely urbanized areas), and 80 percent of its water use is for drinking water, municipal, and industrial uses. SWP exports from the Delta account for roughly 25 percent of the region's water supplies, and local sources (groundwater, surface water, and increasingly recycled water) comprise another 50 percent, and imported water from the Colorado River about 25 percent (DWR 2009). Within the Metropolitan Water District of Southern California, the largest wholesaler in Southern California, the dependence of its member agencies on SWP imports can vary dramatically. Some agencies have few alternative water sources, while others have sufficient local supplies and are now planning to reduce their future reliance on imported water or to roll off the system completely (WBMWD 2010, City of Santa Monica 2012).

With increasing uncertainty over the reliability of Delta water exports, many communities have developed plans and projects to increase and diversify local water supplies and to increase water efficiency. Even with improvements in Delta operations that provide more reliable Delta water exports, regions will need to implement additional local and regional water management strategies to reliably meet their future water demands.

DP-339

Local Water Sources Meet Most of California's Water Needs

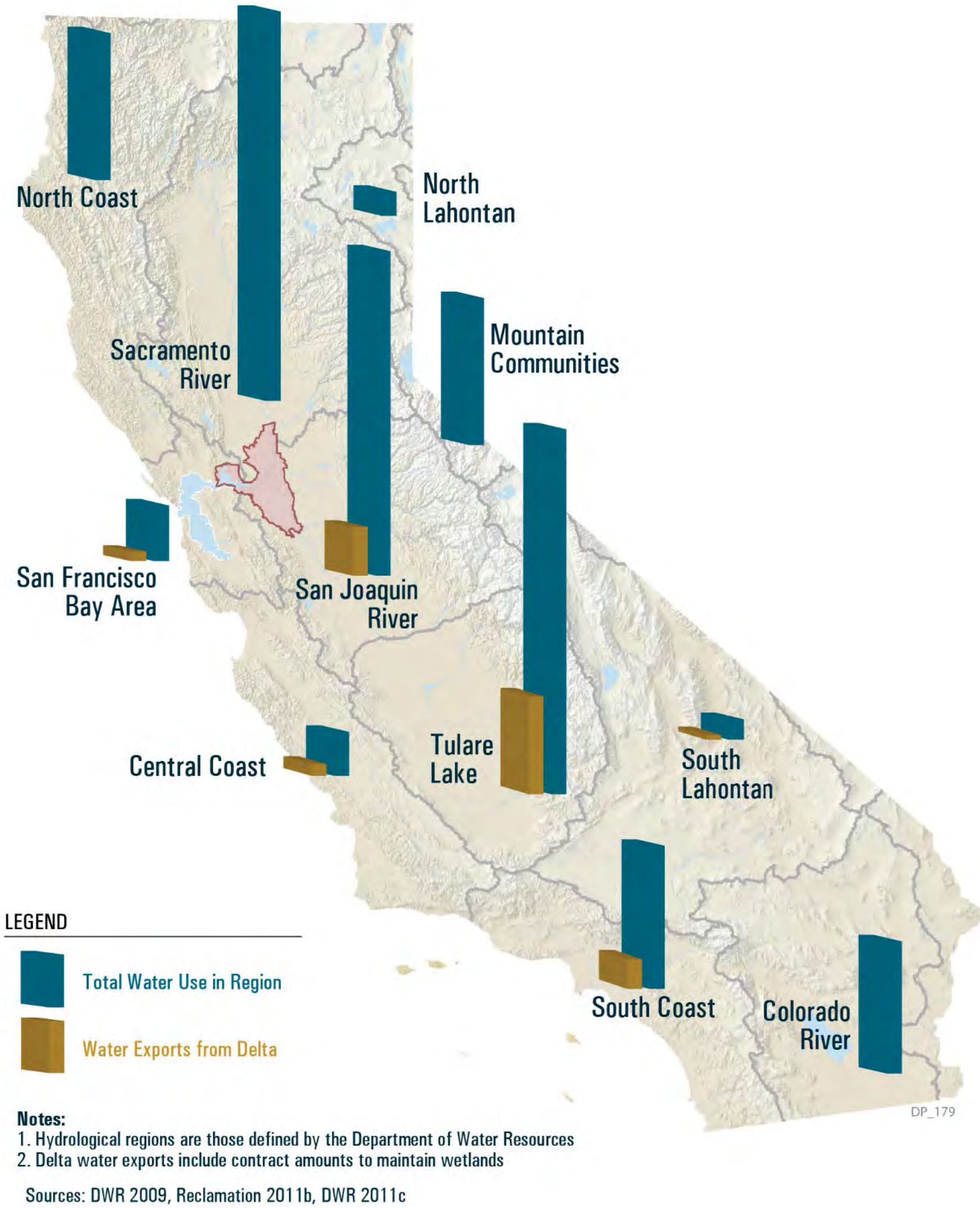


Figure 3-3 The vast majority of California's water comes from local sources. Exports from the Delta comprise 8 percent of California's water use. Yet, the Delta supply is important to many regions south of the Delta.

Within the Delta, growers and residents historically have relied on water from the Delta. In-Delta water use has remained relatively constant over the past 100 years (DWR 2007a) and averages about 4 percent (0.9 MAF) of inflows into the Delta. Most of this water is used for agricultural irrigation, and small and large communities throughout the Delta.

The CVP and SWP export systems became operational in the late 1940s after much of the local Delta development had occurred. Exports from the Delta now range from approximately 3 MAF in dry years to around 6.5 MAF in wet years (DWR 2009, Reclamation 2011b, Reclamation 2011c). In total, the SWP and CVP facilities export on average approximately 5.1 MAF per year from the Delta. These water diversions account for 24 percent of the inflows into the Delta (see Figures 3-4a and 3-4b).

Joint Federal and State Delta Operations

The federal CVP and California SWP were born out of long-range planning documents developed from the 1870s through the 1920s, including the 1919 Marshall Plan completed by U.S. Geological Survey and the 1930 Division of Water Resources Bulletin No. 25, "Report to the Legislature of 1931 on State Water Plan." These planning investigations developed and evaluated alternatives to provide:

- Fresh water to industries in Contra Costa and Alameda counties along Suisun and San Pablo bays
- Irrigation water to portions of the San Joaquin Valley that have substantial and increasing groundwater overdraft conditions, especially in the Tulare Lake region
- Supplemental water for Southern California urban development totaling 2 million acres in San Diego, Orange, and Ventura counties and the San Gabriel and San Bernardino valleys with water from Owens Valley, Mono Basin, and Colorado River

The California Legislature approved this plan in 1941 as the first State Water Plan (now the current California Water Plan), which included a description of facilities that would eventually be constructed as part of the CVP and SWP. Although design and construction of storage and conveyance facilities was done separately for CVP and SWP, both are operated in a coordinated manner for Delta operations.

Central Valley Project

Congress appropriated $20 million in Emergency Relief Appropriation Funds and authorized construction of the CVP by the U.S. Army Corps of Engineers (USACE) as part of the Rivers and Harbors Act of 1935. When the Rivers and Harbors Act was reauthorized in 1937, the construction and operation of the CVP was instead assigned to the Bureau of Reclamation (Reclamation).

Construction of the CVP by the federal government began in 1937. The first water was sold from the CVP to the City of Antioch from the initial reaches of the Contra Costa Canal in 1940, to support shoreline industries.

By the late 1940s, it had become apparent that California's rapid urban, agricultural, and industrial growth would quickly increase demands for water and power to levels that exceeded the initial CVP system capacity. In response, Congress authorized additional federal reservoirs and conveyance facilities over the next few decades, including Folsom Dam along the American River, Tehama-Colusa Canal along the west side of the Sacramento Valley, Trinity River Dam to provide additional water from the Trinity River into the Sacramento River for CVP operations, and New Melones Dam on the Stanislaus River. In 1960, the San Luis Unit, in the western San Joaquin Valley, was authorized by Congress to be constructed under a contract between the federal government and the State.

Where Delta Water Comes From and Goes

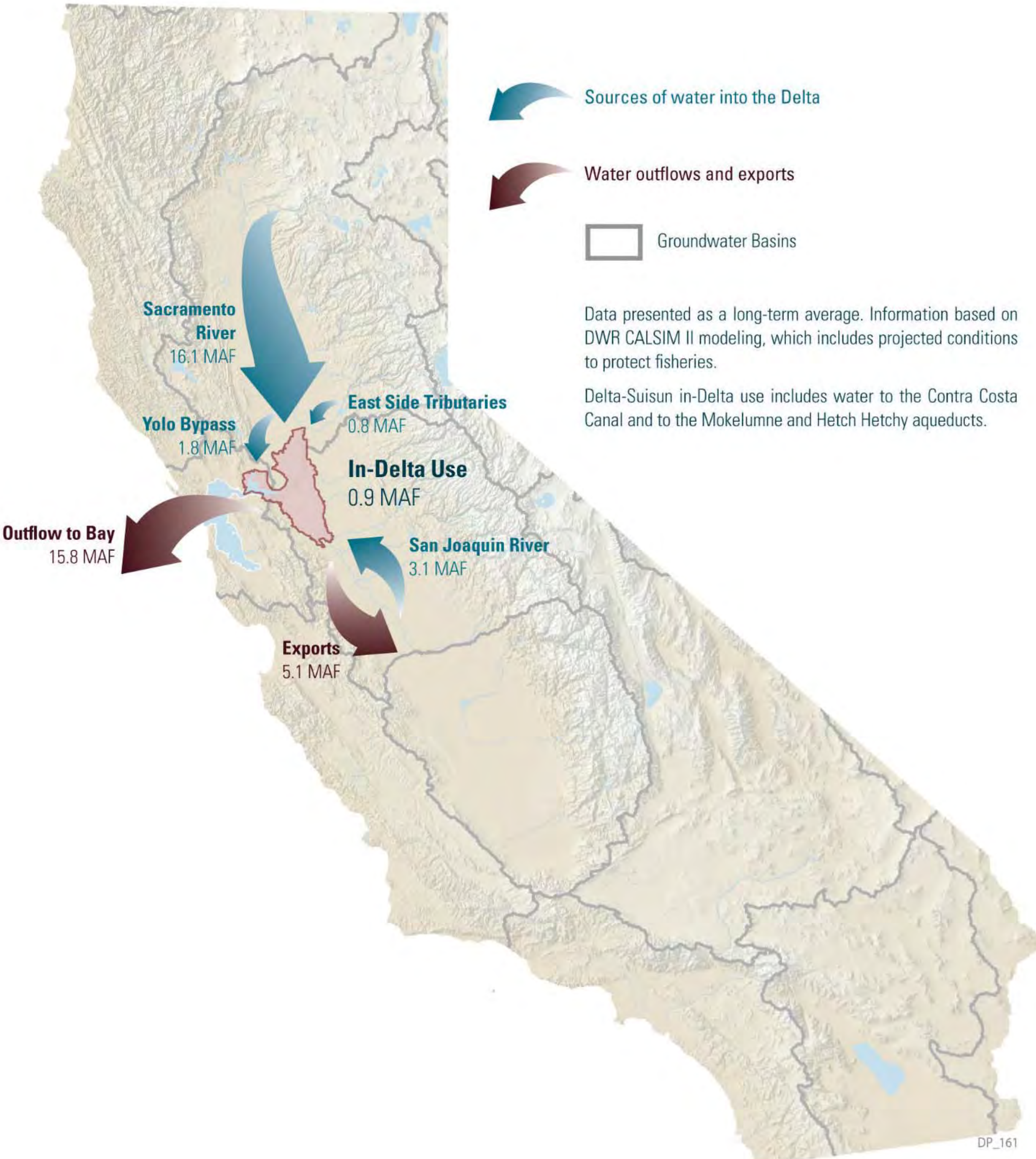


Figure 3-4a Over the past century, the combination of regional diversions from within the Delta watershed and water diverted directly from the Delta has transformed the Bay-Delta ecosystem, reducing historical outflows by an average of 50 percent.

Sources: LAO 2008, Reclamation 2011b, DWR 2011c

Delta Water Flows in Wet and Dry Years

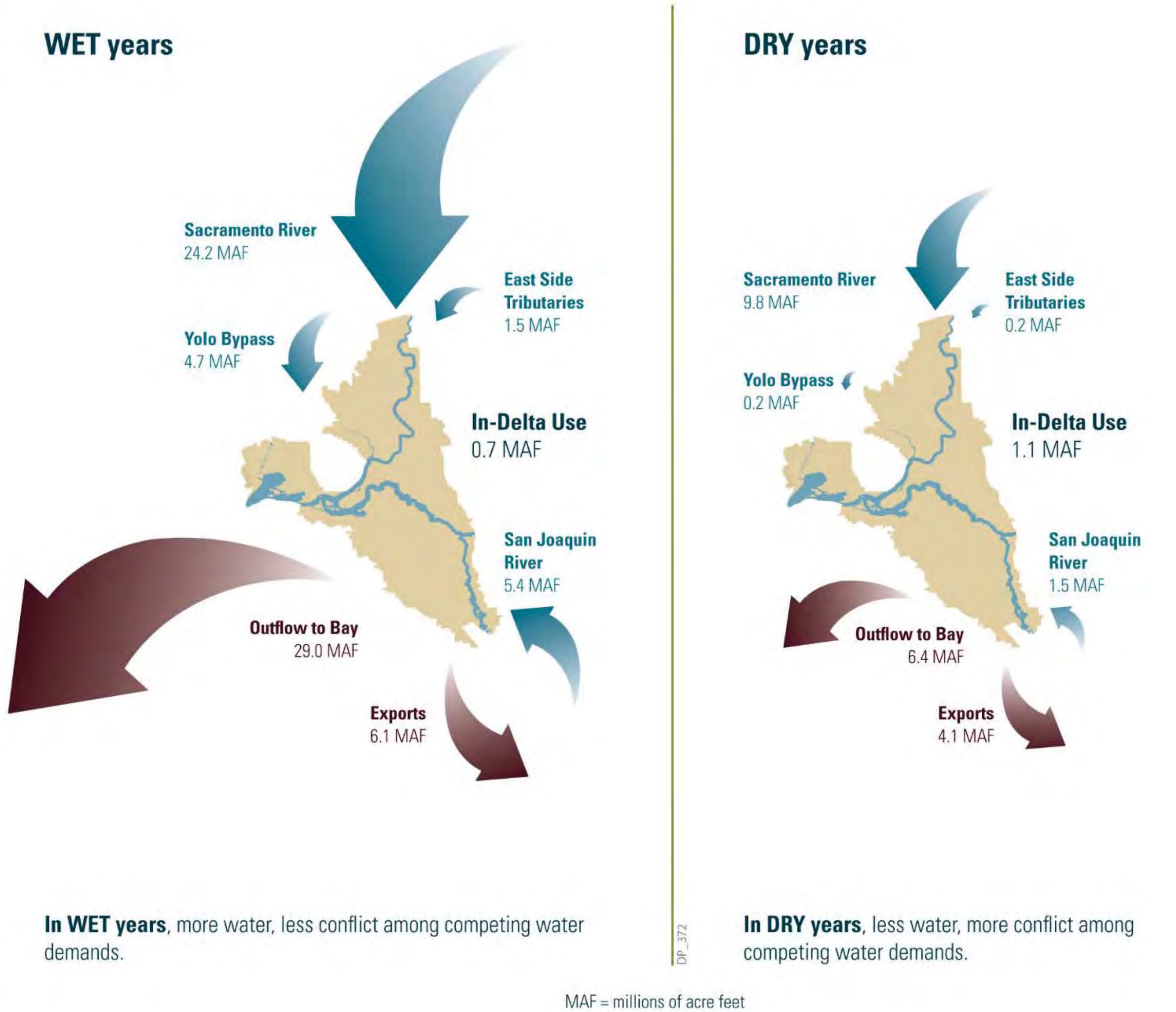


Figure 3-4b *Sources: LAO 2008, Reclamation 2011b, DWR 2011c*

The CVP is the largest surface water storage and delivery system in California, with a geographic scope covering 35 of the state's 58 counties. The project includes 20 reservoirs with a combined storage capacity of approximately 11 MAF, 8 power plants and 2 pumping-generating plants, 2 pumping plants, and approximately 500 miles of major canals and aqueducts. The CVP provides water through water service contracts and water rights agreements for a total of about 9.6 MAF per year (including water service contractors that use water from the Stanislaus River and San Joaquin River).

State Water Project

In 1947, the State began an investigation to consider the next phases of the State Water Plan to meet the state's anticipated supplemental water demands through development of the SWP and to control salinity intrusion in the Delta. In 1953, the State adopted the Abshire-Kelly Salinity Control Barrier Act to evaluate placement of a saltwater barrier near Suisun Bay to protect Delta water users and allow transfer of fresh water from the Sacramento Valley to the San Joaquin Valley. This plan was not implemented primarily due to costs and technical considerations, but alternatives continue to be evaluated today.

In 1957, Bulletin No. 3 was published, which described the need for SWP facilities to convey water from the Sacramento Valley to water-short areas of California. The report identified an urgency to expand statewide water facilities because of projected population growth and to support a balanced economy; major industrial growth; 6,875,000 acres of irrigated agriculture, or approximately 25 percent of all agricultural acreage in the United States; and flood control in Northern California. The study identified that there was a "seasonal deficiency" of 2,675,000 acre-feet of water in 1950 that had been met with groundwater pumping primarily from overdrafted aquifers. In 1960, California voters authorized the Burns-Porter Act to construct the initial projects of the SWP, including Oroville Dam and Lake Oroville on the Feather River, San Luis Dam and Reservoir to be jointly constructed and operated with Reclamation, the North and South Bay aqueducts, and the 444-mile California Aqueduct. Notably, DWR continues to project a 1- to 2-MAF deficit in average annual groundwater pumping from overdrafted aquifers (DWR 2009). A more detailed discussion of groundwater is provided later in this chapter.

Delta Operations

Prior to the 1960s, the CVP and SWP operated in the Delta unrestrained by environmental regulations. However, beginning in the 1970s, with the passage of environmental laws, including the federal Clean Water Act, Endangered Species Act, Central Valley Project Improvement Act, Porter-Cologne Water Quality Control Act, California Endangered Species Act, Wild and Scenic legislation, and many others, protection of the ecosystem became an explicit legal obligation for the SWP and CVP in addition to delivery of fresh water for agricultural and urban use.

In the modern context, CVP and SWP facilities operate according to a complex web of permits, licenses, and, in some cases, court orders that impose explicit conditions on how, when, and how much water can be exported from the Delta. Some of the entities that regulate water project operations in and upstream of the Delta include:

- The SWRCB and regional boards require the SWP and CVP to meet specific water quality criteria that result in operational standards within the Delta and the Delta watershed. The SWRCB also sets instream flow standards.
- USACE sets operational "rule curves" for reservoirs that provide flood protection upstream of the Delta. The Central Valley Flood Protection Board regulates encroachments on designated floodplains and floodways. (See Chapter 7.)
- The presence of threatened and endangered species in California's waterways and landscapes requires the California Department of Fish and Wildlife (DFW), U.S. Fish and Wildlife Service, and National Marine Fisheries Service to regulate water project operations in the Delta. Federal biological opinions that govern agency regulatory activities have been the subject of extensive recent litigation by water agencies and other interested parties.

To comply with these regulations and to optimize system efficiencies, DWR (for the SWP) and Reclamation (for the CVP) jointly coordinate their pumping operations in the Delta under the 1986 Coordinated Operating Agreement (COA). One of the benefits of the COA is that it resulted in improved reliability of deliveries for the SWP (DWR 2008). They also jointly manage portions of the water delivery facilities in the Central Valley. There are times when the CVP may use SWP export capacity or that the SWP may need to use CVP export capacity. This close coordination has resulted in flexible operation of the Delta facilities to improve reliability of Delta water deliveries as well as to reduce system vulnerability to disruption.

Additional operational changes are on the horizon for the CVP and SWP. The SWRCB has initiated a phased process to review and amend—or to adopt new—water quality and flow objectives for the Delta by 2014. Phase 1 of that review is focused on southern Delta water quality and San Joaquin River flows. Phase 2 is focused on other changes that may be needed to the remainder of the Bay-Delta Water Quality Plan to protect fish and wildlife beneficial uses. See Chapter 4 for more information on flow in the Delta and the relationship to ecosystem health, and Chapter 6 for more information on the Council's recommendations on the SWRCB process to update the Bay-Delta Water Quality Plan. Furthermore, conveyance alternatives under consideration by the Bay Delta Conservation Plan (BDCP) could mean large-scale changes to Delta infrastructure and operations.

Challenges and Conflicts in the Delta

Over time, the Delta has been transformed, mostly by human hands, to serve many purposes. As mentioned, the SWP and CVP were originally engineered to reliably deliver water to water service contractors and water rights holders without commensurate consideration for impacts on native species. The Delta is the only saltwater estuary in the world that is used as a conveyance system to deliver fresh water for export. This creates substantial water supply and ecosystem conflicts.

Legal changes in recent decades, combined with growing societal awareness and scientific understanding of water project operations on ecosystem health, had major implications for water operations in the Delta. The collision of changing societal values, growing demands for water deliveries from the Delta, and declining health of the Delta ecosystem have resulted in numerous complex and often bitter legal challenges that have increasingly shifted critical Delta water management decisions to the courts.

CVP and SWP Water Delivery Challenges

Overall, exports from the Delta have been rising over the past 4 decades (see Figure 3-5). Historically, the SWP and CVP have pumped more water from the Delta during dry years than wet years; but over time, exports have increased in all water year types, except in critically dry years. The SWP and CVP have each reached record exports in the past 10 years. In part, this is because recent increases in surface and groundwater storage south of the Delta have enabled more water to be taken during wet years. Increased south-of-Delta storage has also led to more agricultural-to-urban water transfers, which help improve the flexibility of operations in the Delta.

Yet, many factors threaten the ability of State and federal water managers to continue pumping water through the two projects at current export levels. Subsidence of the agricultural lands on the Delta islands, rising sea level, and earthquakes threaten the physical integrity of the Delta ecosystem and the levees that protect the export water quality. The location of the two pumping stations (one each for the CVP and SWP) in the south Delta is a problem for fisheries. Described previously, most of the water enters the Delta from the north through the Sacramento River. Pumping stations for the CVP and SWP are located in the south Delta and, when operating, frequently cause a net "flow reversal" in the central and south Delta channels. (See Chapter 4 for more details.) This reverse flow affects fish movement, including migration through the Delta, and often results in species that are free-floating or have weak swimming capability being drawn into the pumping facilities where they can be entrained (Grimaldo et al. 2009). Water quality is an issue too. A portion of the water flowing into the Delta is specifically allocated to Delta outflow to help repel salinity intrusion from the San Francisco Bay and to maintain low-salinity water near the western edge of the Delta. This means that water that might otherwise be used for exports must be released from upstream reservoirs to help control salinity (NRC 2012).

Historical Exports and In-Delta Use

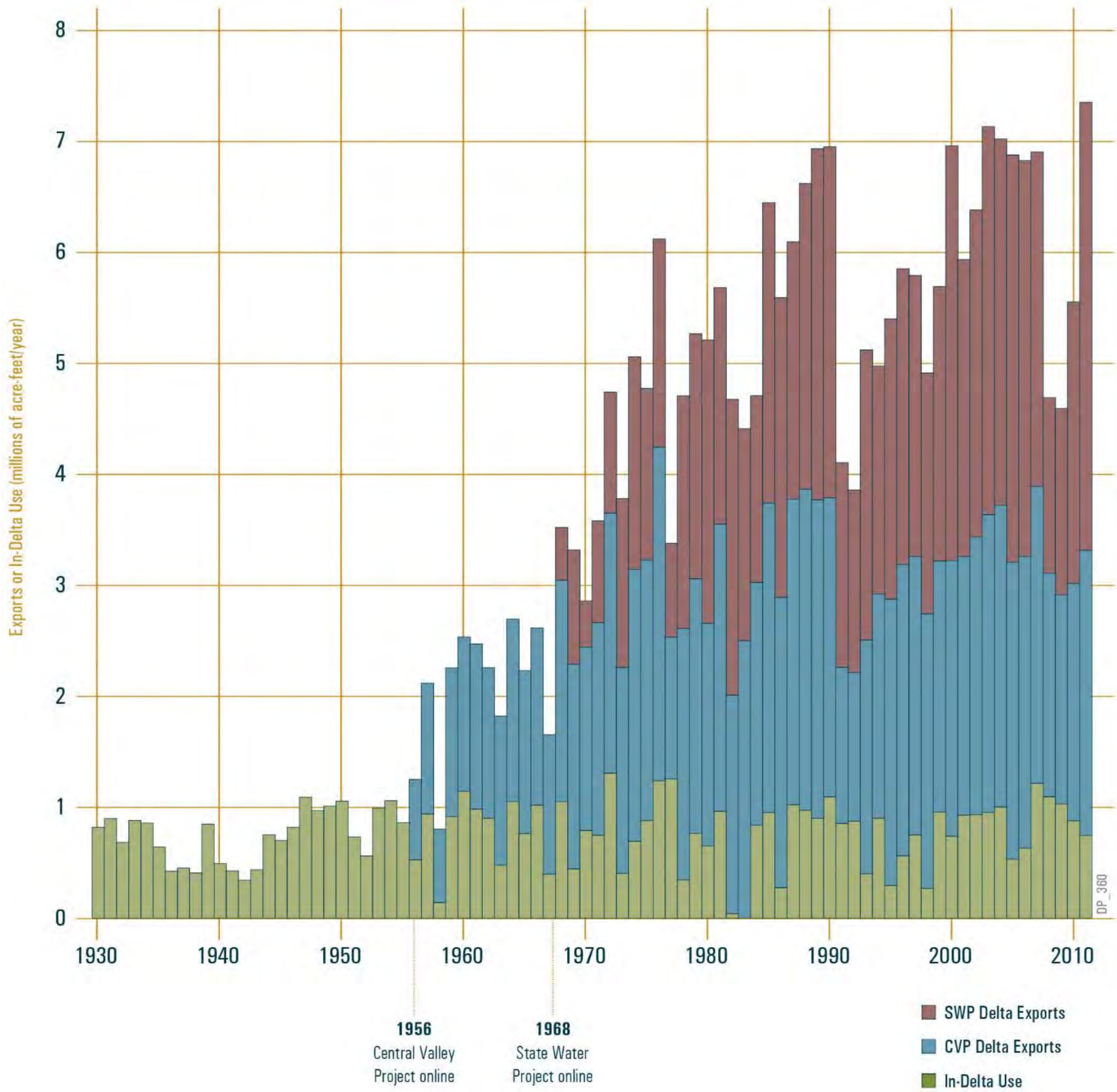


Figure 3-5 Overall exports from the Delta have been rising over the past 4 decades, while in-Delta uses have remained fairly constant. Exports by the CVP and SWP have reached record levels in the past 10 years.

Conflicts over water use are further complicated by original SWP and CVP contracts that assumed greater water export quantities than consistently can be delivered. Since 1990, the CVP has fulfilled 100 percent of its contract water allocations only three times, and the SWP has delivered 100 percent of its contract amounts only twice (Reclamation 2011c, DWR 2010b). The CVP's ability to meet maximum contracted amounts, particularly during dry years, has diminished since the addition of new municipal and industrial contractors who have priority over agricultural water deliveries.[10] Also, the 1992 passage of the Central Valley Project Improvement Act dedicated up to 800,000 acre-feet of CVP exports for wildlife refuges and environmental needs (Public Law 102-575, section 3406(b)(2)). The original SWP contract amounts were based on assumptions that additional major new dams and conveyance facilities would be constructed at a later date, which did not occur. As a result, even though the SWP had contracted to supply 4.2 MAF, average SWP exports between 1996 and 2006 were just 2.9 MAF (DWR 2008).

The reality is that the State and federal systems have never been able to reliably deliver the full contract amounts. Now, additional court-ordered and regulatory restrictions on State and federal pumping of export water, in combination with the 2007 through 2009 drought, further reduced the reliability of Delta water exports to SWP and CVP contractors. According to DWR, SWP deliveries are now expected to average 60 percent of maximum contract amounts in future years, down from 66 to 69 percent estimated in 2005 (DWR 2010b).

The process for allocating water shortages within the State and federal projects also impacts the extent to which various contractors experience different levels of Delta water supply reliability. Within the SWP, shortages are uniformly distributed across all water contractors. Within the CVP, municipal and industrial water users have a higher priority than agricultural water users. As a result, in dry years, CVP water rights contractors, such as the Sacramento River Settlement Contractors, may receive 100 percent of their water allocations while non-water rights contractors, including Westlands Water District, may receive as little as 10 percent.

North-to-south water transfers across the Delta can be an important tool for improving water supply reliability. However, transfers require the use of SWP or CVP facilities and, as such, are subject to the regulatory constraints on Delta exports. Because Delta pumping windows of opportunity are shorter and generally filled by contract deliveries, excess capacity for water transfers is increasingly hard to come by.

Although lesser known, an increasing challenge to Delta export reliability relates to the operations and maintenance of the large, complex facilities that make up the SWP. The SWP has experienced a significant and growing decline in operational reliability that has directly impacted DWR's ability to store and move water, produce electricity, and export water from the Delta when the appropriate hydrological conditions present themselves (DWR 2010b). These challenges include maintaining SWP delivery capabilities under continued manpower resource limitations, aging infrastructure, and constraints in providing competitive employee compensation despite adequate SWP funding. Further resource challenges are attributed to complex and cumbersome State contracting processes and State hiring freezes.

Improving Delta Water Supply Reliability through Investments in System Flexibility

Because California's annual precipitation is remarkably variable, the past expectation that each year—wet or dry—should yield the same quantity of water exported from the Delta watershed is unrealistic and can be an obstacle to necessary improvements in water supply reliability.

[10] Additional municipal and industrial water contracts were implemented in the late 1980s for the CVP San Felipe Unit and in the last 10 years for the CVP American River Division.

The greatest conflicts between the water needs of people and fish within the Delta occur during dry years. That is when the least amount of water is flowing into the Delta and, historically, when exports have been a much larger percentage of Delta inflows than in wet years (see Figure 3-6). On average, exports have diverted about 17 percent of Delta inflows in wet years and about 36 percent during dry years (DWR 2011c). In past years, exports have exceeded 60 percent of Delta inflows in some dry months, but recent regulatory decisions now constrain such operations.

The recovery of the Delta ecosystem and listed species will help reduce regulatory restrictions on Delta exports and increase the long-term stability and predictability of rules governing Delta pumping.

More natural flow patterns in the Delta can be compatible with improving the reliability of water deliveries from the Delta. More water can be taken in wet years when more water is available, less water will be taken in dry years when it is needed for in-Delta water quality and environmental protections, and operations can be improved to increase seasonal flexibility to avoid impacts on Delta species and habitat. Many local water management actions that help reduce reliance on the Delta and improve regional self-reliance are also essential to improving overall flexibility of Delta operations and improving reliability of water supplies during periods when pumping is constrained.

Upstream, downstream, and in-Delta improvements can all add to export system flexibility, producing both water supply and ecosystem benefits. Storage capacity, however, is a current limitation to this scenario, and will worsen under anticipated climate change conditions. Were sufficient storage available, flows that exceed water needed to meet environmental and other requirements could be captured and stored. This stored water could then be released later in the year or carried over into subsequent years.

Fish predation and mortality at the export pumps could be reduced if the diversion points of the State and federal water projects in the Delta were moved or modified. Risks to a reliable source of fresh water conveyed through the Delta could be reduced through conveyance alternatives that could provide multiple diversion locations in the Delta (as those being analyzed in the BDCP process) and through strategic levee investments.

It is important to note that storage can increase the benefits of conveyance improvements, and conveyance improvements may be limited without the benefit of added storage. Improved operational flexibility, consistent with ecosystem restoration, can result in more reliable water supplies for all beneficial uses from year to year and, when managed for multiple benefits, can also ensure adequate flows to meet public trust needs, including the protection of the Delta ecosystem.

The Role of Storage in Increased Flexibility

Statewide water storage capacity, both above and below ground, is currently inadequate, especially south of the Delta, to facilitate export of water at times of surplus when the impacts on the Delta's ecosystem are reduced and the only impediment is lack of available storage capacity (DWR 2009). For example, in 2010, the SWP and CVP pump operations were slowed even though water was available to be pumped at a time when it would not have conflicted with endangered species or other water quality requirements. The SWP and CVP could not convey the surplus water through the Delta at that time because storage capacity south of the Delta was full.

Historical Delta Inflow and Delta Exports

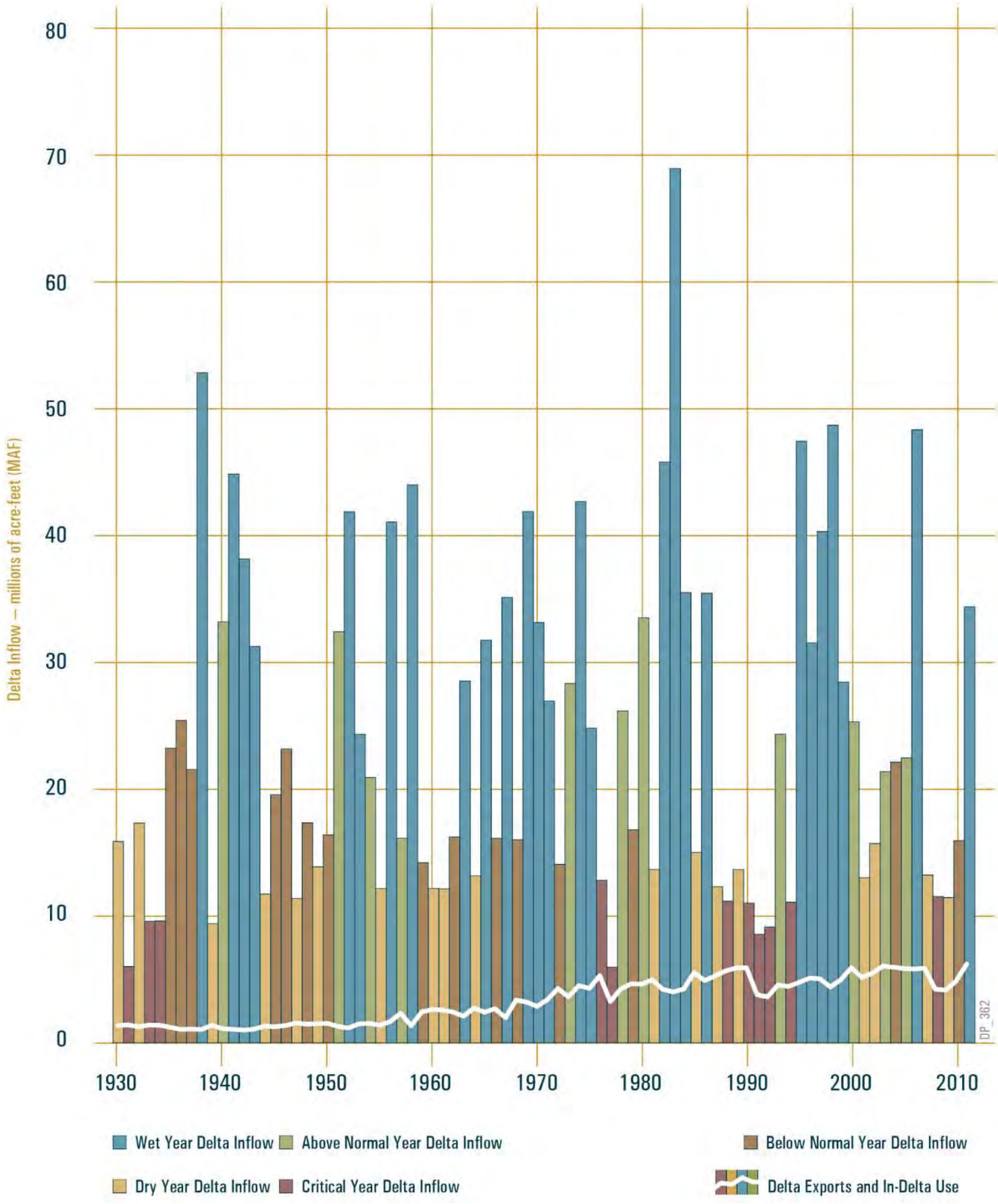


Figure 3-6 In many years, water flowing into the Delta greatly exceeds the amount of water that is exported from or used in the Delta. However, in dry years, total exports and in-Delta use have averaged as much as 36 percent of inflows.

Source: DWR 2012a

Applying Adaptive Management To Water Management Decisions			An adaptive management approach for water management decisions should be taken to plan for and assess the water supply outcomes of conveyance and storage improvement actions. The following is a hypothetical example of how the Council's three-phase and nine-step adaptive management framework (see Appendix C) could be applied to a water management decision.
		Adaptive Management Step	Hypothetical Water Supply Reliability Improvement Project
Plan	1	Define/redefine the problem	Current storage and conveyance configuration is not adequate for providing a more reliable water supply to south-of-Delta users under modern operating rules.
Plan	2	Establish goals and objectives	**Goal:** Improve water supply reliability for south-of-Delta water users. **Objective:** Optimize storage for south-of-Delta water users in wet years so that interruptions in deliveries are reduced and the amount of water delivered during wet years can be increased consistent with environmental regulations in the Delta.
Plan	3	Model linkages between objectives and proposed action(s)	There are inadequate options for south-of Delta water users to optimize storage in wet years, leading to vulnerability to interruptions and reduced capacity to divert water when it is available. The San Luis Reservoir is the only CVP water source for San Luis Unit, Cross-Valley Contractors, and San Felipe Division (SFD) water users. SFD serves water to Santa Clara and San Benito counties. As the San Luis Reservoir is drawn down during the summer and into the late fall (when predictable water supplies are needed most), a dense layer of algae develops near the surface. As the water level lowers, this algae gets captured by SFD intakes. The algae degrade water quality and make water more difficult to treat. As a result, SFD deliveries can be interrupted when the reservoir falls below 300,000 acre-feet. It is hypothesized that improving the San Luis Reservoir low-point intake would increase the predictability of water deliveries and make more water available to south-of-Delta water users during dry years. Alternatives to improving the low-point intake could include expanding the Pacheco Reservoir to provide storage for SFD water users. As a result of taking one or a combination of these actions, progress would be made toward improving water supply reliability for south-of-Delta water users by (1) reducing potential for interruptions, (2) diverting more water during wet years, and (3) making this water available during dry years when water from the Delta may not be available.
Plan	4	Select action(s) (research, pilot, or full-scale) and develop performance measures	**Selected Action:** Conduct feasibility analyses and modeling to determine which option would enable the highest increase in the reliability of water conveyance for south-of-Delta users in compliance with environmental requirements. **Performance Measures:** ▪ Administrative – Complete feasibility analyses and modeling. ▪ Output – Select and implement an improvement project (e.g., improve the low-point intake at San Luis Reservoir only). ▪ Outcome – Progress toward improving water supply reliability by (1) reducing potential for interruptions, (2) diverting more water during wet years, and (3) making this water available during dry years when water from the Delta may not be available.
Do	5	Design and implement action(s)	Design and implement the feasibility analyses and modeling.
Do	6	Design and implement monitoring plan	Design and implement the monitoring plan, including baseline monitoring, and measurement of (1) reduced interruptions of SFD deliveries when the reservoir falls below 300,000 acre-feet, (2) the amount of increased delivery of water during wet years, and (3) the amount of increased water deliveries from the reservoir during dry years to offset reduced Delta diversions.
Evaluate and Respond	7	Analyze, synthesize, and evaluate	Analyze, synthesize, and evaluate the feasibility analyses and model outputs, and make recommendations for selecting a project or adjusting the conceptual model.
Evaluate and Respond	8	Communicate current understanding	Provide project manager(s) and decision makers with synthesized information learned. For example, present information on the extent to which interruptions would be reduced, the value of the reduced interruptions, and the benefits of a specific operation scheme as part of a cost-benefit analysis.
Evaluate and Respond	9	Adapt	The DWR, Reclamation, and SFD contractors decide on a pilot- or full-scale improvement project.

DP-332

In the past decade, the State has spent tens of millions of dollars on integrated studies to evaluate how large surface storage and conveyance may be improved. DWR is now completing surface storage investigations that were initiated under CALFED more than 10 years ago (DWR 2010a). The three proposed new major surface storage reservoirs that are being evaluated are the North-of-the-Delta Offstream Storage (Sites Reservoir), Los Vaqueros Reservoir Expansion, and Upper San Joaquin River Basin Storage investigation (Temperance Flat Reservoir). DWR expects to make its decision on recommended projects by 2014.

In the meantime, smaller facility improvements, particularly for storage, are being implemented. Since 1995, more than 1.2 MAF of additional surface storage has been constructed at the regional level, including the Diamond Valley, Seven Oaks, and Olivenhain reservoirs in Southern California, and the Los Vaqueros Reservoir in Contra Costa County.[11] The sidebar, Applying Adaptive Management to Water Management Decisions, provides a hypothetical example of an approach to providing more reliable water supplies.

A legacy of both overdraft and water quality contamination has compromised groundwater storage in many regions of the state; however, important improvements are being made through expanded regional groundwater storage north and south of the Delta. Notably, an assessment of groundwater storage in 2000 identified more than 21 MAF of potential groundwater storage in Southern California and the southern portion of the San Joaquin groundwater basin (AGWA 2000). A more detailed discussion of groundwater management in California is included later in this chapter.

Significant opportunities are available to improve the operation of existing storage and conveyance facilities, build small-scale storage projects, or enhance opportunities for groundwater conjunctive management and water transfers in the next 5 to 10 years that are consistent with the coequal goals. DWR is leading a System Reoperation Task Force with Reclamation; USACE; and other State, federal, and local agencies to study and assess opportunities for reoperating existing reservoir and conveyance facilities to improve flood protection and capture of available water runoff, particularly in the context of climate change. Reservoir reoperation is also addressed in Chapter 7.

Many local storage and conjunctive management projects were identified through competitive State and federal grant funding application processes in the past decade. Most of these projects could not be funded because of limited funding and restrictions in some of the grant provisions. Later in this chapter, the New Water for California section provides further detail on the range of options and describes necessary steps that regions should take to improve regional self-reliance and reduce reliance on the Delta.

The Role of Conveyance in Increased Flexibility

Conveyance improvements can enhance the operational flexibility of the Delta system to divert and move water at times and from locations that are less harmful to fisheries, or to reliably transport environmental water supplies to specific locations at times when it can benefit fish and water quality (California Natural Resources Agency 2010). Existing configurations of Delta water conveyance and associated conveyance facilities do not provide adequate long-term reliability to meet current and projected water demands for SWP and CVP water exports from the Delta watershed (DWR 2009).

---

[11] Contra Costa Water District will complete a 160,000-acre-foot expansion of Los Vaqueros Reservoir in 2012. The feasibility of an additional 275,000-acre-foot expansion is still under consideration by State and federal agencies.

Conveyance improvements and associated ecosystem restoration actions are being evaluated as part of the multiagency BDCP effort. (See sidebar, Bay Delta Conservation Plan and Water Supply Reliability.) Once decisions are made regarding whether to build and, if so, in what manner to build conveyance improvements, construction of these facilities will likely take at least a decade or more and will not provide near-term reliability improvements. This means that Delta operations and deliveries of export supplies will continue to be constrained by existing infrastructure for at least the next 15 years.

During this time, steps must be taken to implement local water management programs and projects, described later in this chapter. Additionally, the State needs to address the continuing vulnerability of the Delta levee system and make improvements to protect the existing in-Delta conveyance system from catastrophic failure. (See Chapter 7 for a discussion of the benefits and vulnerabilities of Delta levees.) In particular, immediate improvements to the Delta levee system are critical because of the current instability and interdependence of the levees—the failure of one can affect the entire system (NRC 2012).

BAY DELTA CONSERVATION PLAN AND WATER SUPPLY RELIABILITY

The BDCP is a Habitat Conservation Plan (HCP) and Natural Community Conservation Plan (NCCP) that "proposes major physical changes to the Delta, including new diversion and conveyance facilities and their operational criteria, extensive new aquatic habitat, and other measures to help reverse the Delta's ecological decline and secure water supplies from the Delta for human use" (BDCP 2012c).

The BDCP is planned to be implemented over a 50-year timeframe using an adaptive management and monitoring program to adapt as conditions change and new information emerges. The parties seeking one of several permits pursuant to the BDCP include DWR, Reclamation, Metropolitan Water District of Southern California, Kern County Water Agency, Santa Clara Valley Water District, Zone 7 Water Agency, Westlands Water District, and the State and Federal Water Contractors Agency (BDCP 2012a). The goal of these parties, with the exception of Reclamation, is to formulate a plan that could ultimately be approved by the U.S. Fish and Wildlife Service and the National Marine Fisheries Service as an HCP under the provisions of Endangered Species Act section 10(a)(1)(B) and as an NCCP by DFW under Fish and Game Code section 2800 et seq. and/or the California Endangered Species Act section 2050 et seq. Reclamation intends to use information developed as part of the BDCP process to help inform its Endangered Species Act Section 7 consultation on the coordinated long-term operation of the CVP and SWP with the U.S. Fish and Wildlife Service and the National Marine Fisheries Service. If the BDCP is successfully completed, and DFW determines that the BDCP meets the requirements in Water Code section 85320, it must be incorporated into the Delta Plan. That determination by DFW may be appealed to the Council (Water Code section 85320 (e)).

The BDCP is being developed to contribute to improving water supply reliability by modifying Delta conveyance facilities to create a more natural flow pattern in the Delta and allow for water exports when hydrologic conditions result in the availability of sufficient water, consistent with the requirements of State and federal law and the terms and conditions of SWP and CVP water delivery contracts, and other existing applicable agreements.

The BDCP process is considering a range of options for conveying water through or around the Delta:

- **Through-Delta Conveyance:** Continue to divert water in the southern Delta at existing or modified intakes/diversions for SWP and CVP operations.
- **Isolated Conveyance:** Divert water from the Sacramento River at new intakes/diversions and convey the water to the existing SWP and CVP pumping plants through a pipeline/tunnel.
- **Dual Conveyance:** Combine through-Delta conveyance and isolated conveyance to allow operational flexibility.

The BDCP process is ongoing. As of this publication, the public draft of the BDCP and the related environmental impact report/environmental impact statement are planned for release by late 2012, with final documents expected to be released in mid-2013 (BDCP 2012b). The Council is a Responsible Agency for California Environmental Quality Act purposes.

DP-310

New Water for California

The fact that water is a scarce resource does not mean that California is "running out of water" (NRC 2012). It does mean that California will need to develop plans, and implement programs and projects that can adapt to a highly variable and uncertain water future. The primary source of new water supplies for California in the future will come from local and regional sources.

This section discusses local water supply opportunities, the importance of local and regional water management planning, and the need for improved groundwater management and water data so that the state can better match its water demands to the available supplies.

California's Wealth of Water Opportunities

California has many new and underused water resources that can be developed to improve regional self-reliance. In 2009, DWR estimated that the state could further reduce water demand and increase water supplies in the range of 5 to 10 MAF by 2030 through the use of existing strategies and technologies (see Figure 3-7).[12] If the state developed only half this water (about 5 MAF) through water efficiency and new local supplies, it would be sufficient to support the addition of almost 30 million residents, more than the population growth that is expected to occur by 2050.[13]

Nearly all these potential supplies will come from a combination of improved conservation and water use efficiency in the urban and agricultural sectors, local groundwater and surface storage, conjunctive management, recycled water, drinking water treatment, groundwater remediation, and desalination. DWR has identified 27 "resource management strategies" that water suppliers should consider when expanding their water management programs throughout the diverse regions of the state (DWR 2009). Resource managers can combine these strategies into a response package, crafting them to provide multiple water resource benefits, diversify their water portfolio, and become more regionally self-reliant.

Often, the new local and regional water supplies have the additional advantage of being available even during extreme drought conditions, making them some of the most reliable sources of water for urban and agricultural uses. In particular, recycled water and the treatment and reuse of poor-quality groundwater are two of the most resilient water supplies under conditions of drought and climate change. The treatment of poor-quality groundwater also can significantly improve drinking water supplies, especially for rural and economically disadvantaged communities that have limited alternatives to secure clean water. In 2012, the California Legislature enacted Assembly Bill (AB) 685, declaring the established State policy that "every human being has the right to safe, clean, affordable, and accessible water adequate for human consumption, cooking, and sanitary purposes" (Water Code section 106.3 (a)). For more about drinking water quality, see Chapter 6.

For some local water resources, California has adopted specific targets, including:

- **Urban water conservation.** The State's goal is to achieve a reduction in statewide per capita urban water use of 20 percent, from a 2005 baseline of an estimated

[12] The range of 5 to 10 MAF is a conservative estimate and is consistent with recent studies that assess California's potential for increased water savings and water supplies. DWR provides a cautionary note that the water supply benefits summarized in the California Water Plan are not intended to be additive, recognizing the same resource management strategies may complement or compete with one another for funding, system capacity, or other elements that are necessary for implementation. In addition, unlike the 2005 version, DWR did not include in the 2009 California Water Plan an estimate for water supply benefits from improved conveyance. Instead, DWR states that the main benefits of conveyance improvements are increased water supply reliability, water quality protection, and operational flexibility (DWR 2009).

[13] Under California law, water conservation is considered a source of supply (Water Code section 1011(a)). A 2008 report from the Los Angeles Economic Development Corporation found that "using water more efficiently reduces demand, which has the same effect as adding water to the system." For Southern California, the report concludes that "urban water conservation could have an impact equivalent to adding more than 1 MAF of water to the regional supply (about 25 percent of current annual use)" (LAEDC 2008).

198 gallons per capita daily (GPCD) to 166 GPCD (DWR 2012b). This represents a potential annual water savings of approximately 1.8 MAF per year that will be accomplished by 2020. This is consistent with DWR's 2009 estimate that 2.1 MAF can be conserved in roughly the same period through increased use of water-efficient appliances, reduced water use for landscaping, and tiered rate structures, such as increasing block rates or budget-based rate structures.

- **Recycled water.** The State's goal is to increase the use of recycled water over 2002 levels by at least 1 MAF per year by 2020, and by at least 2 MAF per year by 2030 (DWR et al. 2010). DWR's 2009 estimate indicates that as much as 2.25 MAF could be recovered, about half of the amount of wastewater that is treated and released to flow to the ocean.
- **Stormwater runoff.** The State's goal is to increase capture and reuse of stormwater by at least 500,000 acre-feet per year by 2020, and at least 1 MAF per year by 2030 (DWR et al. 2010). The 2008 Scoping Plan for California's Global Warming Solutions Act of 2006 (AB 32) finds that up to 333,000 acre-feet of stormwater could be captured on an annual average for reuse in Southern California alone (CARB 2008).

California's Wealth of New Water Supplies

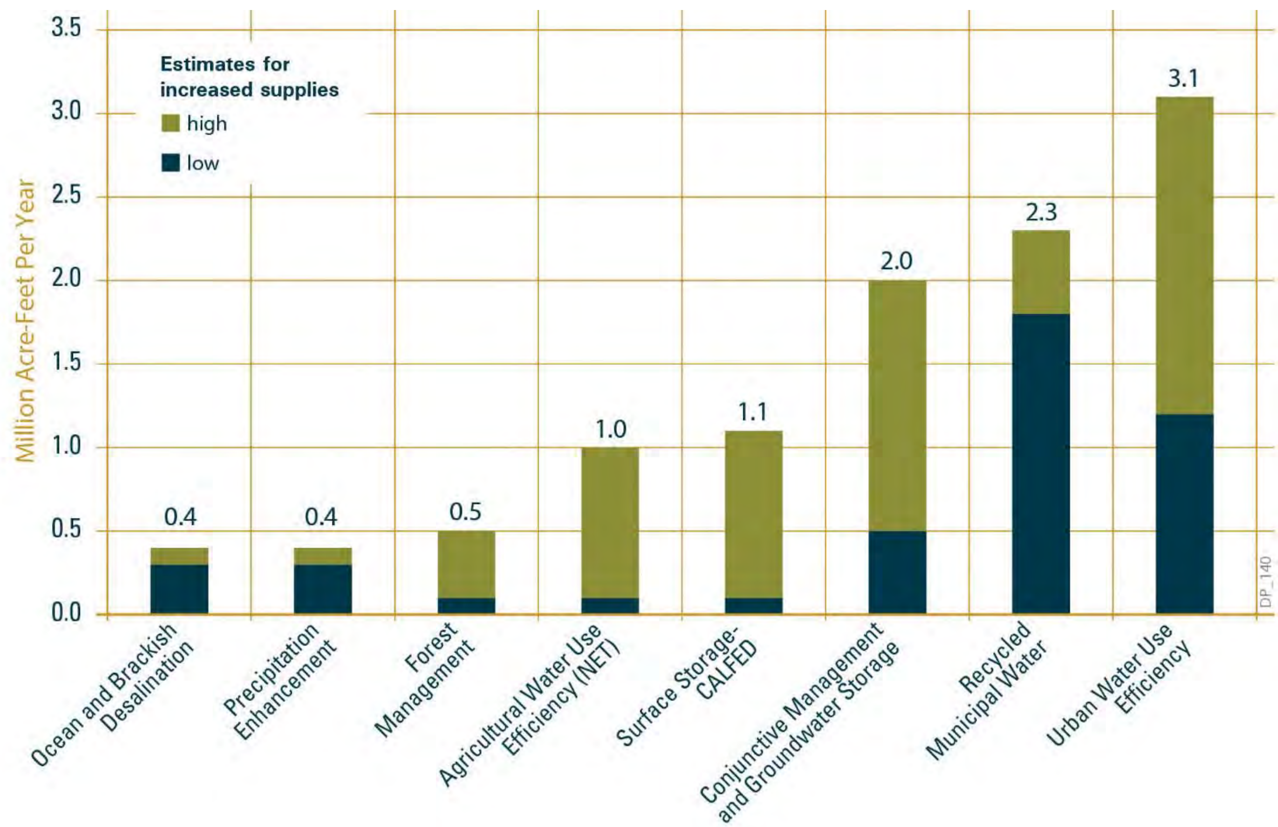


Figure 3-7 DWR estimates that California could further reduce its water demands and increase water supplies by 5 to 10 MAF per year over the next 30 years through the use of existing technologies.

Source: DWR 2009

The Importance of Local Water Management Planning

Over the past few decades, the State has built on successful local water management planning and, when possible, has provided funding for local districts to develop and implement water management plans. These plans are of benefit to all regions, not just those who rely on the Delta or Delta watershed.

These programs and projects increase the reliability of water supplies by increasing water efficiency and diversify the portfolio of water sources for urban and agricultural water suppliers that are more resilient under conditions of drought, emergency shortage, and climate change. Water developed through these activities can help reduce conflicts among urban, agricultural, and environmental uses, and can contribute to the ability of regions in California to reduce their reliance on water from the Delta watershed.[14]

The responsibility for implementing most of these water management strategies and achieving State objectives lies with over 600 local water agencies, including several privately owned and operated companies, plus wastewater districts, community service districts, and other special districts. The sheer number of local agencies engaged in water management makes it difficult to monitor and account for the significant new amounts of water supplies and increased water efficiency that is being implemented. Later in this chapter, the Informed Decision Making Requires Information section details this challenge and associated water management implications.

Since the mid-1980s, California has enacted progressively more stringent water conservation, efficiency, and water planning requirements for urban and agricultural water suppliers (see Appendix H). Beginning in 1983, wholesale and retail municipal water suppliers (those with at least 3,000 connections or delivering at least 3,000 acre-feet per year) have been required by the Urban Water Management Planning Act to prepare 20-year urban water management plans to guide investments in future water reliability. This law has been strengthened through several revisions to include specific water conservation goals (such as the 20 percent reduction in urban per capita water usage by 2020 adopted in 2009), compliance with demand management measures including adoption of rate structures that promote water conservation (AB 1420 in 2007), landscape conservation requirements (AB 1881 in 2006), and required installation of water meters (AB 2572 in 2004).

Existing law requires that urban water suppliers include a water supply reliability element and water shortage provisions in their urban water management plans, recognizing that suppliers need to prepare for extended droughts, the effects of climate change, and potential catastrophic interruption of deliveries caused by earthquakes or other events. Water suppliers must evaluate whether their water sources may be available at a consistent level of use and describe their plans for supplementing or replacing these sources, to the extent practicable with alternatives or water demand management measures (Water Code section 10631(c)(2)). Water suppliers must also describe the tools and options that will be used to maximize resources and minimize the need to

[14] As used in the Delta Plan, "regions" refer to the 10 hydrologic areas identified by DWR that correspond to the state's major water drainage basins, and included the two regional overlays for the Mountain Counties area and the Delta. The use of these regions as planning boundaries allows consistent tracking of their natural water runoff and accounting of surface and groundwater supplies.

import water from other regions (Water Code section 10620(f)).

Agricultural water suppliers (those that provide water to 25,000 or more irrigated acres, or 10,000 irrigated acres and who receive State funding to implement the plan provisions) have a requirement similar to urban suppliers and must prepare agricultural water management plans. The Agricultural Water Management Planning Act was adopted in 2009 (Senate Bill X7 7 [SBX7 7]). Requirements include reporting on farm gate water deliveries, adoption of rate structures that promote water conservation, and identification and implementation of locally cost-effective and technically feasible water efficiency measures.

Since 2000, the State has also promoted voluntary integrated regional water management plans (IRWMPs), recognizing that collaboration among multiple agencies, especially within watersheds, provides opportunities for better water management decisions and coordinated infrastructure investments. Significant bond funding has been made available to support implementation of projects identified through these IRWMPs. A 2006 report on the investments made for IRWMP projects identified over 1.2 MAF of water benefits in combined water supply and demand reductions that have been achieved through the expenditure of $1 billion in State bond funds in local and regional projects (DWR 2009). An additional $1 billion or more of local dollars were leveraged because of this State investment. Applicants for IRWMP funding must now demonstrate how their plans help reduce their region's dependence on water imported from outside their region (DWR 2010c).

As climate change begins to affect California's water supplies, the U.S. Environmental Protection Agency (Region 9) and DWR are encouraging water managers to plan for these impacts and to take steps to adapt to them. IRWMPs, and the agricultural and urban water management plans provide an excellent framework for addressing water-related climate change impacts (USEPA and DWR 2011). Because each region is unique, there is no single "correct" planning approach. Key concepts include risk assessment, such as the potential for interruption of water supplies for up to 36 months due to catastrophic events impacting the Delta, including earthquakes or floods. For example, DWR identified the potential for some portion of Delta deliveries to be interrupted for up to 36 months if a catastrophic earthquake occurred (DWR 2010b). Although this would have a primary impact on water suppliers that rely on water from the Delta, it might also affect upstream water suppliers that may be called upon to release more water into the Delta during the crisis.

Another useful tool is the regional water balance. According to DWR, the purpose of a regional water balance is to provide an accounting of all water that enters and leaves a specific hydrologic region, how it is used, and how it is exchanged between regions. A regional water balance can be used to compare how water supplies and uses in a region can vary between wet and critically dry hydrologic conditions, and how each region's water balance compares with other regions and with the state's overall water balance. This is important to all water planning activities and provides a basis for evaluating unsustainable water management practices and making appropriate improvements (DWR 2009).

Implementing a Path to Success in Local Water Management

Many agricultural and urban water suppliers are taking commendable action to improve water conservation and efficiency, and to expand their local and regional water supplies. (See sidebar, Regional Success Stories.) However, others are not.

For example, despite longstanding State laws that require preparation and implementation of urban water management plans, many water suppliers still regard these plans as voluntary because the only consequence of not completing them has been ineligibility to receive State grant and loan funding

REGIONAL SUCCESS STORIES

Significant improvements in water management are being implemented throughout California, especially in regions that rely upon water from the Delta and the Delta watershed. The 2010 urban water management plan updates and voluntary IRWMP grant applications filed in 2010 provide insight into what individual water agencies and regional planning efforts are doing to improve water efficiency and develop additional local water supplies. Examples of successful strategies to reduce reliance on the Delta and improve regional self-reliance follow.

In Southern California:

- **West Basin Municipal Water District.** Increased water efficiency and diversification of the district's water supplies between 2010 and 2035 will enable West Basin Municipal Water District to reduce its potable water demand despite expected future population growth. The total volume of imported water usage is projected to decline by 40,000 acre-feet over this period, and conservation, recycled water, and ocean desalination will expand the district's water resources by over 60,000 acre-feet (RMC Water and Environment 2011).
- **City of Los Angeles.** Today the City of Los Angeles uses less water than it did 30 years ago, despite population growth of more than 1 million residents. In 2011, per capita water usage was 123 gallons daily—the lowest in Los Angeles in more than 40 years and the lowest among any United States city with a population over 1 million (LADWP 2012). Through regional watershed planning efforts, the city is bringing together local and county public works departments, planning agencies, local and regional water supplies, and citizen groups to develop integrated multibenefit projects. In 2004, the city overwhelmingly approved Proposition O, which authorized $500 million in local bonds to fund water efficiency, stormwater capture, water treatment, recycled water, flood protection, open space, recreation, and other projects.

In the central San Joaquin Valley and Tulare Lake regions:

- **Poso Creek Regional Water Management Group.** The IRWMP focuses on more effective coordination of each participating irrigation district's water assets, recognizing that competition for the three sources of water that meet the region's demands (local supplies/Kern River, CVP, and SWP) is increasing. Proposed improvements include 400 acres of spreading ponds and additional conveyance (canals, pipelines, and pumping plants) between the Friant-Kern Canal and California Aqueduct and among irrigation districts, which will enable the region to take advantage of wet-year (unscheduled) water diversions from the Delta and reduce diversions in dry years (Semitropic Water Storage District 2011).

In the Delta:

- **East Contra Costa County.** Located entirely within the statutory Delta, all the water suppliers that participate in this IRWMP rely upon the Delta for more than 80 percent of average-year water demands, with three water suppliers receiving 100 percent. The IRWMP priorities for reducing reliance on the Delta include expanded use of recycled water, installation of water meters, increased water conservation, and new wellhead treatment for groundwater supplies (Contra Costa Water District 2011).

In the Bay Area:

- **City and County of San Francisco.** Increased water efficiency has resulted in general decline in total consumption and per capita water use since the mid-1970s to record low levels in the state despite growth in the county's population. Recognition of the vulnerability of the city's Hetch Hetchy Reservoir and aqueduct system to earthquakes and other emergencies, San Francisco is working to diversify its local water supplies, including increased conservation, new local groundwater wells, expansion of recycled water, use of gray water, rainwater harvesting, and participation in the Bay Area Regional Desalination Project with Contra Costa Water District, East Bay Municipal Utility District, Santa Clara Valley Water District, and Zone 7 Water Agency (San Francisco Public Utilities Commission 2011).

In the Delta upper watershed:

- **American River Basin.** The IRWMP features reduced reliance on water in the Delta's American River tributaries through expanded conjunctive use operations, development of recycled water, and increased water conservation. More water will be diverted during wetter periods and made available as groundwater in drier periods, which will help increase regional water supply reliability while improving flow and temperature conditions that benefit salmon and steelhead fisheries in the lower American River (Regional Water Authority 2011).

DP-348

to implement water projects. In the 2005 round of urban water management plan submittals, this incentive increased the number of plans submitted over previous years; however, only 75 percent of agencies that should submit plans actually did as of December 31, 2006, and more than 50 percent of these failed to include required conservation or drought contingency plans (DWR 2006). In the 2010 round of urban water management plan submittals, 66 percent of the agencies required to submit plans actually did by the August 2011 deadline. One year later, this percentage had increased to 85 percent, but no assessment for completeness has been performed (DWR 2012b).

Widespread compliance with existing water management laws alone would achieve great progress in improving water supply reliability for California. Compliance with all State water efficiency and management statutes and policies, at a minimum, should be the starting point for assessing a water supplier's reasonable use of California's water. In particular, water suppliers that do not engage in efficient use of water, particularly where the implementation of proven measures and technologies are economically justifiable, locally cost effective, and do not harm other water users, should be held accountable for wasting water. The SWRCB should be encouraged to use its authority to prevent waste and unreasonable use by seeking enforcement of these requirements. The potential for this type of action was anticipated in the Water Conservation Act of 2009 (SBX7 7), which explicitly recognized that the failure of urban water suppliers to reduce urban per capita water demand consistent with the State's 20 percent by 2020 conservation targets can be used after January 2021 to establish a violation of the law for the purposes of State administrative or judicial proceedings (Water Code section 10608.8(a)(2)).

Importantly, for those who prepare them, urban water management plans and integrated regional water management plans appear to be working. As a result of these efforts and increased irrigation efficiency, the amount of water needed to meet future urban and agricultural demands has changed. Since 1980, the total volume of water used in the urban and agricultural sectors has declined. Urban areas that have implemented the strongest water conservation programs show the greatest improvements in water efficiency and the largest reductions in water use (see Figure 3-8).

Groundwater Overdraft Is an Impediment to the Coequal Goals

Groundwater is a major source of water supply for nearly every region in California and a vital component of the state's water storage system, particularly during droughts (DWR 2009). More than 40 percent of Californians rely on groundwater for part of their water supply, and many small- to moderate-sized towns and cities are entirely dependent on groundwater for their drinking water systems (DWR 2003a). The state's most significant groundwater use occurs in regions that also rely on water from the Delta watershed, including the San Joaquin Valley, Tulare Lake, Sacramento Valley, Central Coast, and South Coast (see Figures 3-9 and 3-10). The Tulare Lake region alone accounts for more than one-third of the state's total groundwater pumping (DWR 2009). Because of historical groundwater overdraft and resulting land subsidence experienced in these regions, water users switched to using surface water from the CVP and SWP when the water projects were completed in the late 1960s. However, groundwater pumping and overdraft continued to become more severe as water demands continued to exceed available supplies. Recent satellite imaging revealed that the Central Valley lost approximately 25 MAF of stored groundwater during the period of October 2003 to March 2010 (Famiglietti et al. 2011).

As a result of use continually exceeding recharge, many of California's groundwater basins are in overdraft, and groundwater levels are declining over the long term (Faunt 2009). In some areas, overdraft can lead to a permanent loss of groundwater storage. According to DWR, a groundwater basin is in a state of "critical overdraft" when continuation of present water management practices would result in significant adverse overdraft-related environmental, social, or economic impacts. DWR estimates statewide average overdraft of about 1 to 2 MAF per year (DWR 2009). Groundwater use is also increasing, and is expected to grow at a faster rate in future decades as climate change reduces the reliability of surface water deliveries and increases the potential for extended droughts (DWR 2009). Without more efficient management, the state's groundwater resources will be significantly impacted, and in severe overdraft conditions, the aquifer's capacity to store groundwater may be irretrievably lost (DWR 2003a). Improved management is also needed to take advantage of opportunities to store water underground, particularly to aid flexibility when done in coordination with improved operations in the Delta.

California has established laws, regulations, and programs to protect the quality of its groundwater resources. Despite the major importance of this water supply to California, however, the quantity of groundwater used by agencies or individuals is largely unregulated at the State level. Except for Texas, California is the only state where use of its groundwater resources is managed at the local rather than State level. The lack of State oversight means that limited and often incomplete information is available to the public about how California's groundwater basins are being managed. So little is known, that in 2003, DWR was unable to revise the designation of critically overdrafted basins in its update on California's groundwater (DWR 2003a). Lacking current information and having limited resources to complete additional investigations, DWR simply republished the list of 11 basins identified in 1980.

Trends in California's Water Use

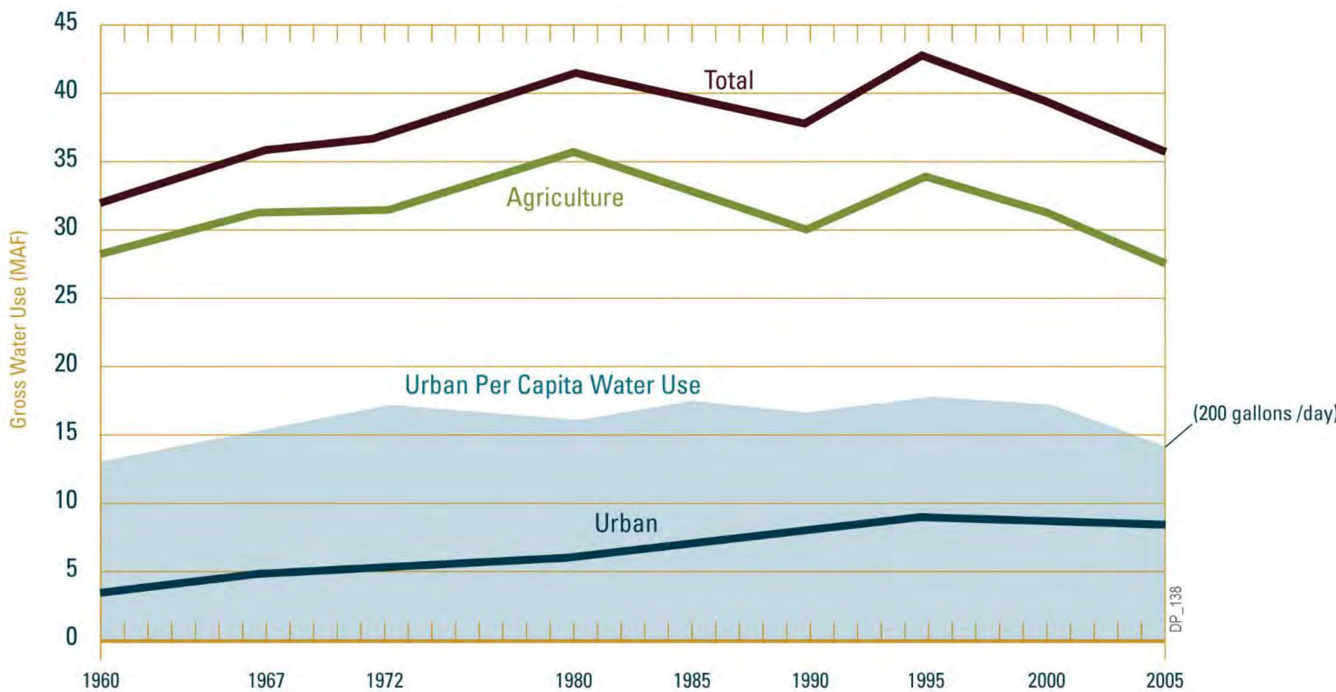


Figure 3-8

California's water use is declining, primarily due to increased water efficiency in both agricultural and urban areas. The City of Los Angeles, like many other cities, reports that it is using the same amount of water as it did over 30 years ago, even though its population has grown by more than 1 million people.

Sources: Hanak et al. 2011; adapted from DWR 2009

Critically Overdrafted Groundwater Basins

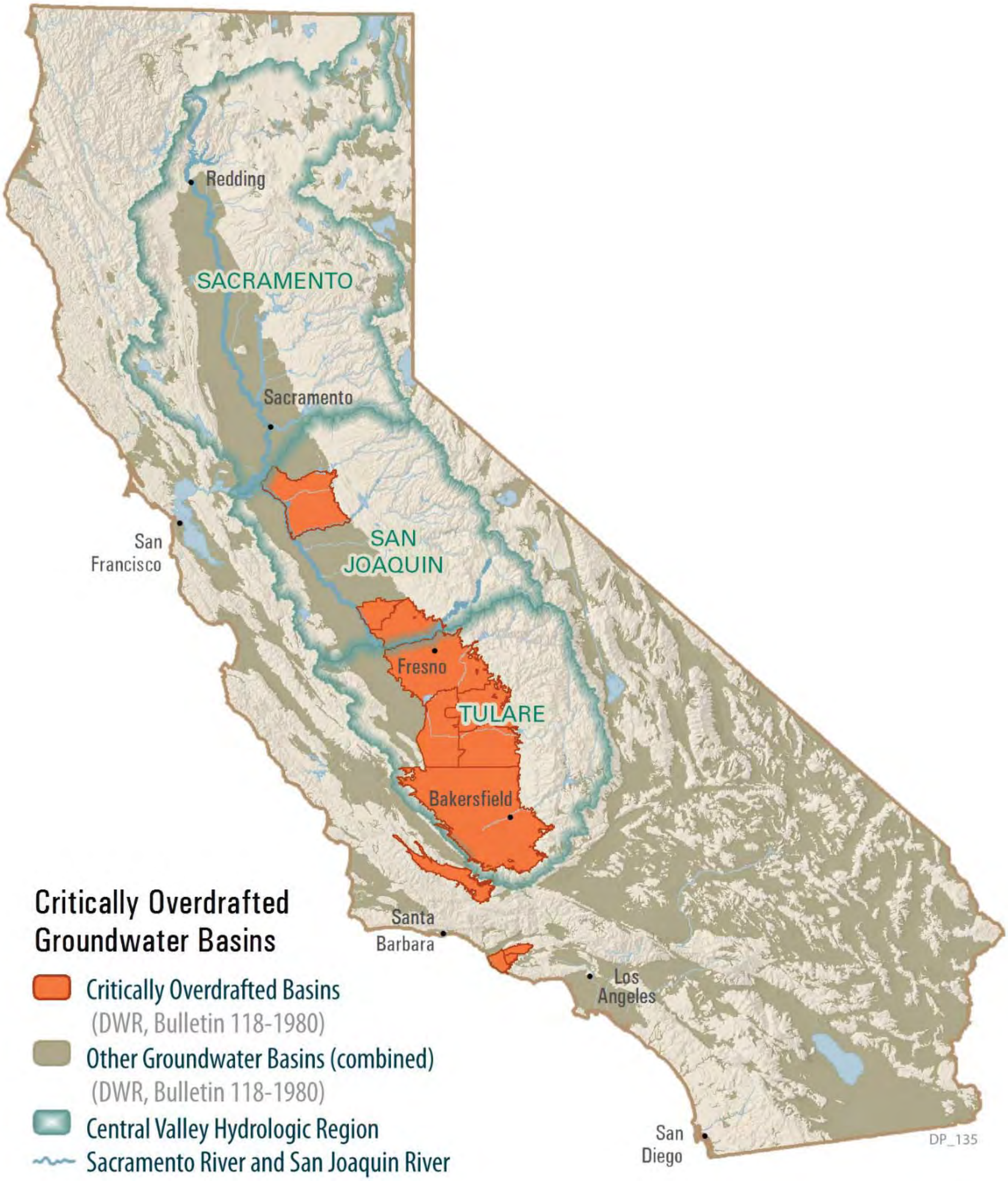


Figure 3-9

Groundwater overdraft is a critical water supply problem, especially in the Central Valley. More than 40 percent of Californians rely on groundwater for some portion of their supply, and many small- and moderate-sized communities are entirely dependent on groundwater for drinking water.

Sources: DWR 2003a; DWR 2009

San Joaquin Groundwater Pumping Is Unsustainable

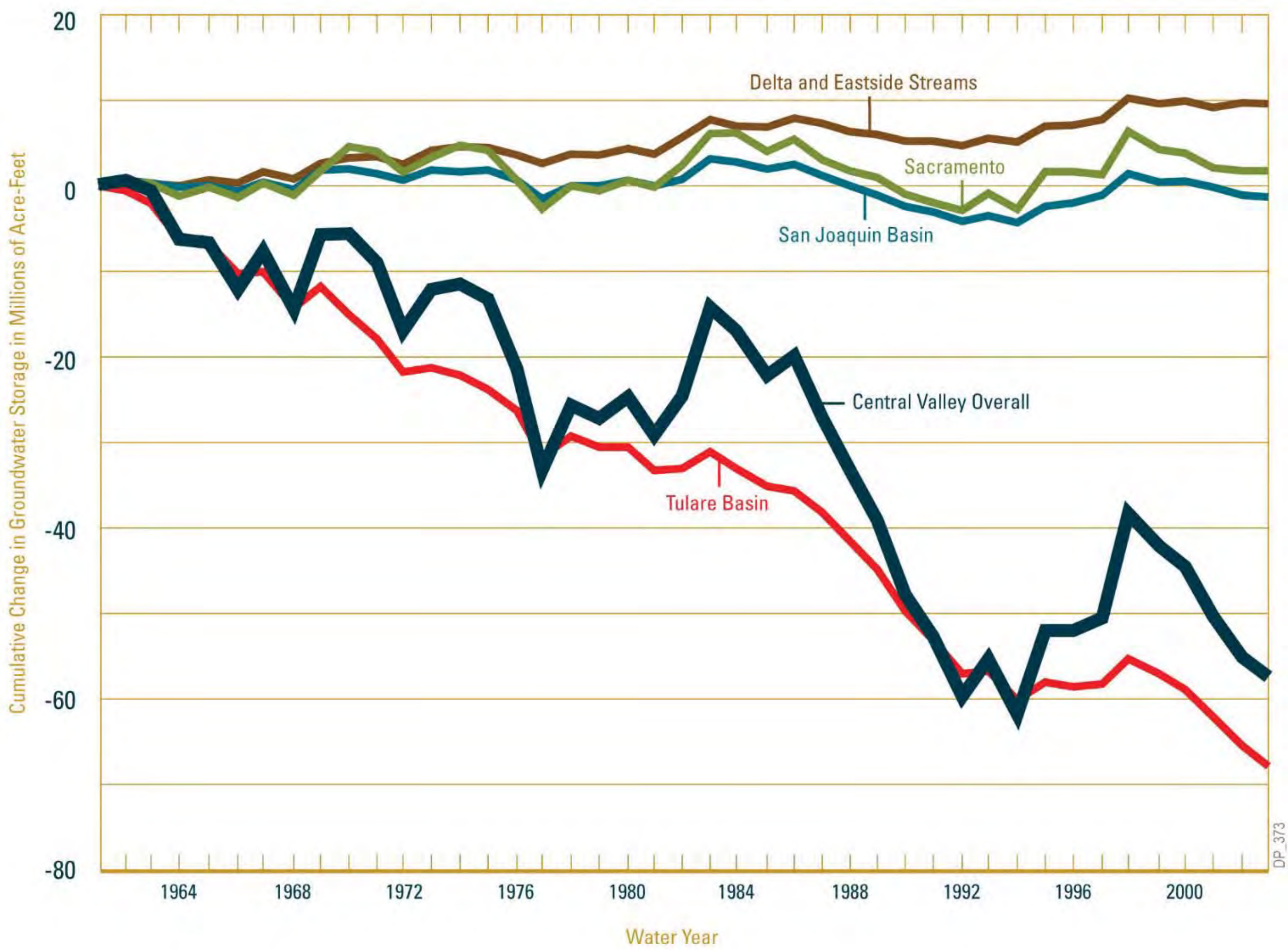


Figure 3-10

Estimated cumulative annual changes in groundwater storage in the Tulare Lake Basin due to over-pumping are more than 60 MAF since 1960. Serious land subsidence and loss of groundwater storage capacity impacts more than half of this region.

Source: Faunt 2009

Some regions appear to be making significant progress in developing sustainable groundwater management programs through regional water balances and voluntary groundwater management plans (known as AB 3030 plans), local ordinances, and court adjudications (Nelson 2011).[15] In 2009, the State created a mandatory statewide program for local reporting of groundwater elevation data, the California Statewide Groundwater Elevation Monitoring Program. This program will collect reported groundwater elevations and make the data available online.

Informed Decision Making Requires Information

One of the greatest challenges to California water management is the lack of consistent, comprehensive, and accurate estimates of actual water use by the type of use (agricultural, urban, and environmental) and by hydrologic region. The water use that is reported to the State is a combination of measured uses and estimated use that are not measured, with limited verification of actual water use. This means that California does not have a clear understanding of its water demands, the amount of water available to meet those demands, how water is being managed, and how that management can be improved to achieve the coequal goals for the Delta.

Key concerns include:

- Not all water uses are required to be monitored and measured. Many water rights were issued decades ago when water measurement was not required. Until reforms were approved by the California Legislature in 2009, water rights holders were not required to provide detailed information on water diversions and use. As a result, total diversion amounts are currently unknown and may be over-allocated in some locations or during dry periods (SWRCB 2008, SWRCB 2011, NRC 2012). Similarly, many groundwater withdrawals are not monitored or reported.
- Not all water users report data even when they are required to do so. A 2009 report prepared for the Legislature by the SWRCB on the development of a coordinated measurement database indicated that historically, about 67 percent of water permit and license holders actually report their water use information, and fewer than 35 percent of other water right claimants who are required to report actually do so (SWRCB 2009).
- SWP contractors are not required by DWR to provide data similar to that collected by Reclamation for CVP contractors. Reclamation has established best management practices for water efficiency, consistent with the federal Reclamation Reform Act and the Central Valley Project Improvement Act, and performs a "Water Needs Assessment" for each federal contractor with input from that contractor. Reclamation also requires contractors to submit an annual report that includes a full water balance (production from all sources, system losses, and changes in storage and water), and implement an effective water conservation and efficiency program based on the contractor's approved water conservation plan (Reclamation 2011b).
- SWP contract amendments in the past have not always been developed and approved in a transparent manner, and have resulted in litigation over implications for the management of the state's water supplies. In 2003, as part of a legal settlement, DWR adopted policies for how future contracts and contract amendments would be reviewed and adopted through an open and transparent process (DWR 2003b). Consistent application of this policy is important (see Appendix B).
- More detailed information on changes in groundwater levels, rates of groundwater extraction, and the location

[15] The State encourages additional voluntary development of locally controlled groundwater monitoring programs and related management plans through AB 3030 (1992), AB 303 (2000), AB 599 (2001), and SB 1938 (2002); through the IRWMP Program (through funding provided by Propositions 13, 50, and 84); and by limiting availability of State funding for water infrastructure to those agencies that have adequate groundwater management plans in place. The State also provides technical assistance to help local agencies more efficiently and sustainably manage groundwater resources, and has identified 14 required and recommended components for groundwater plans. Prior to 2002, there were no required elements for groundwater plans.

of basins with severe and chronic overdraft is needed as a baseline for the State's water resource management efforts. Basic groundwater management data (estimates of safe yield, monitoring of changes in storage in the aquifers and water quality conditions, and identification of replenishment sources and connections with surface water supplies) need to be quantified for many areas, but especially in those regions that rely upon water from the Delta watershed (DWR 2003a). The State's goal should be to sustainably maintain and maximize long-term reliability of these groundwater supplies, with a focus on preventing significant degradation of groundwater quality (DWR 2003a, ACWA 2011).

Recent legislation has resulted in significant improvements to the State's water monitoring and reporting requirements. However, time and resources will be necessary to assess the results from these improvements, which will also serve to inform future Delta Plan updates. For example, recently enacted provisions are now being implemented for:

- Groundwater monitoring (Water Code section 10920 et seq.)
- In-Delta and statewide water diversion reporting (Water Code section 5100 et seq.)
- In-Delta enforcement investigations under the authority of the Delta Watermaster (Water Code section 85230)
- Compliance with the State's goal of achieving a 20 percent reduction in statewide urban per capita water use by 2020 (Water Code section 10608 et seq.)
- Improved reporting on agricultural water use efficiency measures (Water Code section 10608 et seq. and 10800 et seq.)

In late 2010, the SWRCB also adopted regulations requiring online reporting of water use by all water rights holders, including appropriative, riparian, and pre-1914 surface water users, and groundwater users. Since 2008, DWR, SWRCB, and the California Department of Public Health have been working to develop a coordinated database to track the urban and agricultural water use data that are provided to each agency. This tool is central to the development of a statewide integrated system for streamlined data collection and analysis that will support improved water management in California.

POLICIES AND RECOMMENDATIONS

Policies and recommendations for providing a more reliable water supply for California are based on four core strategies:

- Increase water conservation and expand local and regional supplies
- Improve groundwater management
- Improve conveyance and expand storage
- Improve water management information

Increase Water Conservation and Expand Local and Regional Supplies

Approximately 84 percent of California's water supplies come from local and regional sources, including surface runoff, groundwater, recycled water, and water made available through advanced treatment. Improved management of these resources, including water conservation and efficiency, is central to the state's ability to better match its demands to the amount of supply that is available. Over the next 30 years, the *California Water Plan Update 2009* estimates that, with the use of existing technology, the state can reduce its demands and increase its water supplies in the range of 5 to 10 MAF. This is more than enough water to meet California's projected water demands beyond 2050 and to sustain its economic vitality.

The State's constitutional principle of reasonable use and the Public Trust Doctrine form the legal foundation for California's water management policies. Importantly, along with the coequal goals, the Delta Reform Act also established a new policy for California of reducing reliance on the Delta and improving regional self-reliance in meeting California's future water supply needs. The Delta Reform Act mandates many strategies that the Delta Plan must address to improve water supply reliability for California including water efficiency and conservation, wastewater reclamation and recycling, desalination and advanced water treatment technologies, improved water conveyance, surface and groundwater storage, improved water quality, and implementation of local and regional water supply projects and coordination (see Water Code sections 85004(b), 85020(d) and (f), 85201, 85023, 85303, and 85304).

An assessment of future water supply reliability is now required in urban water management and agricultural water management plans, as well as in voluntary regional water planning documents known as IRWMPs. In areas that rely upon water from the Delta watershed, water suppliers will need to identify, evaluate, and implement locally cost-effective and technologically feasible measures that reduce their reliance on the Delta and improve regional self-reliance.

Problem Statement

The lack of participation by some water suppliers throughout California to implement laws, programs, and projects that improve water efficiency, expand local and regional water supplies, and reduce reliance on the Delta and the Delta watershed contributes to higher water demands, less water supply to meet these demands, greater pressure on the Delta ecosystem for its water, and more vulnerability to the impacts of climate change and catastrophic events. Given the Delta Reform Act mandates to improve water supply reliability for California, reduce reliance on the Delta, and improve regional self-reliance, at a minimum, all water suppliers should demonstrate full compliance with State water efficiency and management laws, goals, and regulations to demonstrate reasonable and beneficial use of the state's water resources. California's success in achieving the policy of reduced reliance on the Delta and improving regional self-reliance will be demonstrated through a significant reduction in the amount of water used or in the percentage of water used from the Delta watershed. See Appendix G for additional information regarding how to achieve reduced reliance on the Delta and improved regional self-reliance.

Policies

WR P1. Reduce Reliance on the Delta through Improved Regional Water Self-Reliance

(a) Water shall not be exported from, transferred through, or used in the Delta if all of the following apply:

(1) One or more water suppliers that would receive water as a result of the export, transfer, or use have failed to adequately

contribute to reduced reliance on the Delta and improved regional self-reliance consistent with all of the requirements listed in paragraph (1) of subsection (c);

(2) That failure has significantly caused the need for the export, transfer, or use; and

(3) The export, transfer, or use would have a significant adverse environmental impact in the Delta.

(b) For purposes of Water Code section 85057.5(a)(3) and section 5001(j)(1)(E) of this Chapter, this policy covers a proposed action to export water from, transfer water through, or use water in the Delta, but does not cover any such action unless one or more water suppliers would receive water as a result of the proposed action.

(c) (1) Water suppliers that have done all of the following are contributing to reduced reliance on the Delta and improved regional self-reliance and are therefore consistent with this policy:

(A) Completed a current Urban or Agricultural Water Management Plan (Plan) which has been reviewed by the California Department of Water Resources for compliance with the applicable requirements of Water Code Division 6, Parts 2.55, 2.6, and 2.8;

(B) Identified, evaluated, and commenced implementation, consistent with the implementation schedule set forth in the Plan, of all programs and projects included in the Plan that are locally cost effective and technically feasible which reduce reliance on the Delta; and

(C) Included in the Plan, commencing in 2015, the expected outcome for measurable reduction in Delta reliance and improvement in regional self-reliance. The expected outcome for measurable reduction in Delta reliance and improvement in regional self-reliance shall be reported in the Plan as the reduction in the amount of water used, or in the percentage of water used, from the Delta watershed. For the purposes of reporting, water efficiency is considered a new source of water supply, consistent with Water Code section 1011(a).

(2) Programs and projects that reduce reliance could include, but are not limited to, improvements in water use efficiency, water recycling, stormwater capture and use, advanced water technologies, conjunctive use projects, local and regional water supply and storage projects, and improved regional coordination of local and regional water supply efforts.

23 CCR Section 5003
NOTE: Authority cited: Section 85210(i), Water Code.
Reference: Sections 10608, 10610.2, 10610.4, 10801, 10802, 85001(c), 85004(b), 85020(a), 85020(d), 85020(h), 85021, 85022(d)(1), 85022(d)(5), 85023, 85054, 85300, 85302(d), 85303, and 85304, Water Code.

Recommendations

WR R1. Implement Water Efficiency and Water Management Planning Laws

All water suppliers should fully implement applicable water efficiency and water management laws, including urban water management plans (Water Code section 10610 et seq.); the 20 percent reduction in statewide urban per capita water usage by 2020 (Water Code section 10608 et seq.); agricultural water management plans (Water Code section 10608 et seq. and 10800 et seq.); and other applicable water laws, regulations, or rules.

WR R2. Require SWP Contractors to Implement Water Efficiency and Water Management Laws

The California Department of Water Resources should include a provision in all State Water Project contracts, contract amendments, contract renewals, and water transfer agreements that requires the implementation of all State water efficiency and water management laws, goals, and regulations, including compliance with Water Code section 85021.

WR R3. Compliance with Reasonable and Beneficial Use

The State Water Resources Control Board should evaluate all applications and petitions for a new water right or a new or changed point of diversion, place of use, or purpose of use that would result in new or increased long-term average use of water from the Delta watershed for consistency with the constitutional principle of reasonable and beneficial use. The State Water Resources Control Board should conduct its evaluation consistent with Water Code sections 85021, 85023, 85031, and other provisions of California law. An applicant or petitioner should submit to the State Water Resources Control Board sufficient information to support findings of consistency, including, as applicable, its urban water management plan, agricultural water management plan, and environmental documents prepared pursuant to the California Environmental Quality Act.

WR R4. Expanded Water Supply Reliability Element

Water suppliers that receive water from the Delta watershed should include an expanded water supply reliability element, starting in 2015, as part of the update of an urban water management plan, agricultural water management plan, integrated water management plan, or other plan that provides equivalent information about the supplier's planned investments in water conservation and water supply development. The expanded water supply reliability element should detail how water suppliers are reducing reliance on the Delta and improving regional self-reliance consistent with Water Code section 85201 through investments in local and regional programs and projects, and should document the expected outcome for a measurable reduction in reliance on the Delta and improvement in regional self-reliance. At a minimum, these plans should include a plan for possible interruption of water supplies for up to 36 months due to catastrophic events impacting the Delta, evaluation of the regional water balance, a climate change vulnerability assessment, and an evaluation of the extent to which the supplier's rate structure promotes and sustains efficient water use.

WR R5. Develop Water Supply Reliability Element Guidelines

The California Department of Water Resources, in consultation with the Delta Stewardship Council, the State Water Resources Control Board, and others, should develop and approve, by December 31, 2014, guidelines for the preparation of a water supply reliability element so that water suppliers can begin implementation of WR R4 by 2015.

WR R6. Update Water Efficiency Goals

The California Department of Water Resources and the State Water Resources Control Board should establish an advisory group with other State agencies and stakeholders to identify and implement measures to reduce impediments to achievement of statewide water conservation, recycled water, and stormwater goals by 2014. This group should evaluate and recommend updated goals for additional water efficiency and water resource development by 2018. Issues such as water distribution system leakage should be addressed. Evaluation should include an assessment of how regions are achieving their proportional share of these goals.

WR R7. Revise State Grant and Loan Priorities

The California Department of Water Resources, the State Water Resources Control Board, the California Department of Public Health, and other agencies, in consultation with the Delta Stewardship Council, should revise State grant and loan ranking criteria by December 31, 2013, to be consistent with Water Code section 85021 and to provide a priority for water suppliers that includes an expanded water supply reliability element in their adopted urban water management plans, agricultural water management plans, and/or integrated regional water management plans.

WR R8. Demonstrate State Leadership

All State agencies should take a leadership role in designing new and retrofitted State-owned and -leased facilities, including buildings and California Department of Transportation facilities, to increase water efficiency, use recycled water, and incorporate stormwater runoff capture and low-impact development strategies.

Improve Groundwater Management

Groundwater is the source, on average, of 20 percent of California's urban and agricultural water supplies. The state's most significant groundwater use occurs in regions that also rely upon water from the Delta watershed. In many of these groundwater basins, more water is pumped than is recharged, and groundwater levels are declining over the long term. The ***California Water Plan Update 2009*** estimates that the state, on average, overdrafts its groundwater basins by about 1 to 2 MAF per year and that the level of unsustainable groundwater pumping is increasing.

Problem Statement

The continued existence of major California groundwater basins in a chronic condition of overdraft combined with key regions of the state that depend on water from the Delta watershed and have poor groundwater practices, including unsustainable groundwater pumping, water quality contamination, irreversible loss of groundwater storage, and no groundwater plan for addressing these problems, is a major impediment to the achievement of the coequal goals.

Policies

No policies with regulatory effect are included in this section.

Recommendations

WR R9. Update Bulletin 118, California's Groundwater Plan

The California Department of Water Resources, in consultation with the Bureau of Reclamation, U.S. Geological Survey, the State Water Resources Control Board, and other agencies and stakeholders, should update Bulletin 118 information using field data, California Statewide Groundwater Elevation Monitoring (CASGEM), groundwater agency reports, satellite imagery, and other best available science by December 31, 2014, so that this information can be included in the next California Water Plan Update and be available for inclusion in 2015 urban water management plans and agricultural water management plans. The Bulletin 118 update should include a systematic evaluation of major groundwater basins to determine sustainable yield and overdraft status; a projection of California's groundwater resources in 20 years if current groundwater management trends remain unchanged; anticipated impacts of climate change on surface water and groundwater resources; and recommendations for State, federal, and local actions to improve groundwater management. In addition, the Bulletin 118 update should identify groundwater basins that are in a critical condition of overdraft.

WR R10. Implement Groundwater Management Plans in Areas that Receive Water from the Delta Watershed

Water suppliers that receive water from the Delta watershed and that obtain a significant percentage of their long-term average water supplies from groundwater sources should develop and implement sustainable groundwater management plans that are consistent with both the required and recommended components of local groundwater management plans identified by the California Department of Water Resources Bulletin 118 (Update 2003) by December 31, 2014.

WR R11. Recover and Manage Critically Overdrafted Groundwater Basins

Local and regional agencies in groundwater basins that have been identified by the California Department of Water Resources as being in a critical condition of overdraft should develop and implement a sustainable groundwater management plan, consistent with both the required and recommended components of local groundwater management plans identified by the California Department of Water Resources Bulletin 118 (Update 2003), by December 31, 2014. If local or regional agencies fail to develop and implement these plans, the State Water Resources Control Board should take action to determine if the continued overuse of a groundwater basin constitutes a violation of the State's Constitution Article X, Section 2, prohibition on unreasonable use of water and whether a groundwater adjudication is necessary to prevent the destruction of or irreparable injury to the quality of the groundwater, consistent with Water Code sections 2100 and 2101.

Improve Conveyance and Expand Storage

The greatest conflicts between the water needs of people and fish within the Delta occur during dry years. That is when the least amount of water is flowing into the Delta and, historically, when exports have been a much larger percentage of Delta inflows compared with wet years. The timing and pattern of Delta diversions must be shifted so that more water can be exported during wet years, when there is significantly more water available for diversion, and less is taken in dry years, when the water is needed for in-Delta water quality and ecosystem protections.

The ability to export larger amounts of water from the Delta during wet years will require improved conveyance to increase operational flexibility as well as more storage both north and south of the Delta so that this water can be captured, stored, and ultimately delivered to meet the water needs of both people and fish. With these improvements, Delta operations and, importantly, Delta export deliveries will become more predictable.

As an interim step toward increasing California's water supply reliability, the State should identify, prioritize, and implement smaller and more incremental operational, conveyance, and storage improvements (such as expanding existing facilities or constructing new ones) that can be accomplished quickly, preferably within the next 5 to 10 years.

Problem Statement

The state's interconnected network of surface and groundwater storage is insufficient in volume, conveyance capacity, and flexibility to achieve the coequal goals. The completion of the BDCP and the implementation of major new surface and groundwater storage facilities are needed but may take many years to implement, which will require more near-term actions to improve Delta operations and reduce the state's vulnerability to potential disruptions in water exports from the Delta due to floods and earthquakes or the need for additional regulatory protections for the environment.

Policies

No policies with regulatory effect are included in this section. See Appendix A, The Delta Stewardship Council's Role Regarding Conveyance.

Recommendations

WR R12. Complete Bay Delta Conservation Plan

The relevant federal, State, and local agencies should complete the Bay Delta Conservation Plan, consistent with the provisions of the Delta Reform Act, and receive required incidental take permits by December 31, 2014.

WR R13. Complete Surface Water Storage Studies

The California Department of Water Resources should complete surface water storage investigations of proposed off-stream surface storage projects by December 31, 2012, including an evaluation of potential additional benefits of integrating operations of new storage with proposed Delta conveyance improvements, and recommend the critical projects that need to be implemented to expand the state's surface storage.

WR R14. Identify Near-term Opportunities for Storage, Use, and Water Transfer Projects

The California Department of Water Resources, in coordination with the California Water Commission, Bureau of Reclamation, State Water Resources Control Board, California Department of Public Health, the Delta Stewardship Council, and other agencies and stakeholders, should conduct a survey to identify projects throughout California that could be implemented within the next 5 to 10 years to expand existing surface and groundwater storage facilities, create new storage, improve operation of existing Delta conveyance facilities, and enhance opportunities for conjunctive use programs and water transfers in furtherance of the coequal goals. The California Water Commission should hold hearings and provide recommendations to the California Department of Water Resources on priority projects and funding.

WR R15. Improve Water Transfer Procedures

The California Department of Water Resources and the State Water Resources Control Board should work with stakeholders to identify and recommend measures to reduce procedural and administrative impediments to water transfers and protect water rights and environmental resources by December 31, 2016. These recommendations should include measures to address potential issues with recurring transfers of up to 1 year in duration and improved public notification for proposed water transfers.

Improved Water Management Information

One of the greatest challenges to improved management of California's water supplies is the lack of consistent, comprehensive, and accurate estimates of actual water use in the state, both by sector of use (agricultural, urban, and environmental) and by regions within the state. The sheer number of water management agencies in California is a key logistical factor. Current data reported to various State agencies is a combination of measured uses and estimated uses, with limited verification of actual water use. This means that California does not have a clear understanding of its water demands, the amount of water available to meet those demands, how water is being managed, and how that management can be improved to achieve the coequal goals.

Problem Statement

Accurate, timely, consistent, and transparent information on the management of California water supplies and beneficial uses is an important tool used in the achievement of the coequal goals. The State needs sufficient information to assess the current reliability of its water supplies or to meaningfully measure progress toward achievement of more reliable water supplies for California.

Policies

The appendices referred to in the policy language below are included in Appendix B of the Delta Plan.

WR P2. Transparency in Water Contracting

(a) The contracting process for water from the State Water Project and/or the Central Valley Project must be done in a publicly transparent manner consistent with applicable policies of the California Department of Water Resources and the Bureau of Reclamation referenced below.

(b) For purposes of Water Code section 85057.5(a)(3) and section 5001(j)(1)(E) of this Chapter, this policy covers the following:

(1) With regard to water from the State Water Project, a proposed action to enter into or amend a water supply

or water transfer contract subject to California Department of Water Resources Guidelines 03-09 and/or 03-10 (each dated July 3, 2003), which are attached as Appendix 2A; and

(2) With regard to water from the Central Valley Project, a proposed action to enter into or amend a water supply or water transfer contract subject to section 226 of P.L. 97-293, as amended or section 3405(a)(2)(B) of the Central Valley Project Improvement Act, Title XXXIV of Public Law 102-575, as amended, which are attached as Appendix 2B, and Rules and Regulations promulgated by the Secretary of the Interior to implement these laws.

23 CCR Section 5004
NOTE: Authority cited: Section 85210(i), Water Code.
Reference: Sections 85020, 85021, 85300, and 85302, Water Code.

Recommendations

WR R16. Supplemental Water Use Reporting

The State Water Resources Control Board should require water rights holders submitting supplemental statements of water diversion and use or progress reports under their permits or licenses to report on the development and implementation of all water efficiency and water supply projects and on their net (consumptive) use.

WR R17. Integrated Statewide System for Water Use Reporting

The California Department of Water Resources, in coordination with the State Water Resources Control Board, California Department of Public Health, California Public Utilities Commission, California Energy Commission, Bureau of Reclamation, California Urban Water Conservation Council, and other stakeholders, should develop a coordinated statewide system for water use reporting. This system should incorporate recommendations for inclusion of data needed to better manage California's water resources. The system should be designed to simplify reporting; reduce the number of required reports where possible; be made available to the public online; and be integrated with the reporting requirements for the urban water management plans, agricultural water management plans, and integrated regional water management plans. Water suppliers that export water from, transfer water through, or use water in the Delta watershed should be full participants in the database.

WR R18. California Water Plan

The California Department of Water Resources, in consultation with the State Water Resources Control Board and other agencies and stakeholders, should evaluate and include in the next and all future California Water Plan updates information needed to track water supply reliability performance measures identified in the Delta Plan, including an assessment of water efficiency and new water supply development, regional water balances, improvements in regional self-reliance, reduced regional reliance on the Delta, and reliability of Delta exports, and an overall assessment of progress in achieving the coequal goals.

WR R19. Financial Needs Assessment

As part of the California Water Plan Update, the California Department of Water Resources should prepare an assessment of the state's water infrastructure. This should include the costs of rehabilitating/replacing existing infrastructure, an assessment of the costs of new infrastructure, and an assessment of needed resources for monitoring and adaptive management for these projects. The California Department of Water Resources should also consider a survey of agencies that may be planning small-scale projects (such as storage or conveyance) that improve water supply reliability.

Timeline for Implementing Policies and Recommendations

Figure 3-11 lays out a timeline for implementing the policies and recommendations described in the previous section. The timeline emphasizes near-term and intermediate-term actions.

Timeline for Implementing Policies and Recommendations

TIMELINE | **CHAPTER 3: Reliable Water Supply**

	ACTION (REFERENCE #)	LEAD AGENCY(IES)	NEAR TERM 2012–2017	INTERMEDIATE TERM 2017–2025
POLICIES	Reduce reliance on the Delta through improved regional water self-reliance (WR P1)	Water suppliers	●	●
POLICIES	Transparency in water contracting (WR P2)		●	●
RECOMMENDATIONS	Implement water efficiency and water management planning laws (WR R1)	Water suppliers	●	●
RECOMMENDATIONS	Require State Water Project contractors to implement water efficiency and water management laws (WR R2)	DWR	●	●
RECOMMENDATIONS	Compliance with reasonable and beneficial use (WR R3)	SWRCB	●	●
RECOMMENDATIONS	Expanded water supply reliability element (WR R4)	Water suppliers receiving Delta water	●	
RECOMMENDATIONS	Develop water supply reliability element guidelines (WR R5)	DWR	●	
RECOMMENDATIONS	Update water efficiency goals (WR R6)	DWR and SWRCB	●	●
RECOMMENDATIONS	Revise State grant and loan priorities (WR R7)	DWR, SWRCB, and DPH	●	
RECOMMENDATIONS	Demonstrate State leadership (WR R8)	State agencies	●	●
RECOMMENDATIONS	Update Bulletin 118, California's Groundwater Plan (WR R9)	DWR	●	●
RECOMMENDATIONS	Implement groundwater management plans in areas that receive water from the Delta watershed (WR R10)	Water suppliers receiving Delta water and uses groundwater	●	
RECOMMENDATIONS	Recover and manage critically overdrafted groundwater basins (WR R11)	Local and regional agencies	●	●
RECOMMENDATIONS	Complete Bay Delta Conservation Plan (WR R12)	Federal, State, and local agencies	●	●
RECOMMENDATIONS	Complete surface water storage studies (WR R13)	DWR	●	
RECOMMENDATIONS	Identify near-term opportunities for storage, use, and water transfer projects (WR R14)	DWR	●	
RECOMMENDATIONS	Improve water transfer procedures (WR R15)	DWR	●	
RECOMMENDATIONS	Supplemental water use reporting (WR R16)	SWRCB	●	
RECOMMENDATIONS	Integrated statewide system for water use reporting (WR R17)	DWR	●	●
RECOMMENDATIONS	California Water Plan (WR R18)	DWR	●	
RECOMMENDATIONS	Financial needs assessment (WR R19)	DWR	●	●

DP_342

Agency Key:

Council: Delta Stewardship Council
DPH: California Department of Public Health
DWR: California Department of Water Resources
RWQCB: Regional Water Quality Control Board(s)
SWRCB: State Water Resources Control Board
Water suppliers: refers to both urban and agricultural water suppliers

Figure 3-11

Science and Information Needs

An improved understanding of the state's hydrologic systems, patterns of water use, and effects of climate change, especially within the Delta watershed and areas that receive water from the Delta, is essential to improving the management of California's water supplies to achieve the coequal goals. Key areas of needed research include:

- Improved projections for and measurement of surface water flows (amounts, timing, quality) and how they may be impacted by environmental regulations, changing land uses, and climate change
- Improved water supply and demand forecasting models that incorporate vulnerability to extreme events (droughts, floods, earthquakes) and account for the impacts of climate change
- Improved methods for downscaling climate change models (including dynamic downscaling) and improved models for water scenario planning that incorporates these data
- Improved information on effective watershed management actions to restore and enhance capacity of rural and urban landscapes to process stormwater for water quality and water supply benefits
- Improved models for assessing the interaction between water management scenarios in the Delta and ecosystem function, including implications of revised instream flow requirements on inflows to the Delta and revised wet year/dry year export scenarios
- Improved information on changing water use patterns in response to urban and agricultural water efficiency measures, including water pricing, and implications for future water demands
- Improved characterization of groundwater basins and subbasins, and improved estimates of groundwater supplies (amounts, quality)
- Improved models of aquifer and surface-groundwater relationships, which include the effects of climate change on evaporation, runoff, groundwater recharge, subsurface interactions, and the implications of these effects for safe yield and implementation of conjunctive use and water transfer programs

Issues for Future Evaluation and Coordination

Additional areas of interest and concern related to water supply and the Delta may deserve consideration in the development of future Delta Plan updates, including:

- **Delta water delivery predictability.** A Delta Delivery Predictability Index should be developed that depicts, by hydrologic year types, the estimated streamflows entering the Delta and suggested levels of water exports that would be consistent with in-Delta and ecosystem protections. As part of the index, a system for tracking the use of stored Delta water also should be developed. The index will lead to a better understanding of how water exported and stored during wet years would be available to urban and agricultural users during dry years to offset reduced exports. This information is key to better understanding how investments in new storage and improved conveyance contribute to improved reliability of California's water supplies.
- **Performance measures for reduced reliance on the Delta.** The Delta Plan identifies two core measures for assessing progress in reducing reliance on the Delta: (1) a significant reduction in the amount of water used from the Delta watershed, or (2) a significant reduction in the percentage of water used from the Delta watershed. The Council will collaborate with DWR, SWRCB, and stakeholders to develop a standardized method or methods by which progress to reduce reliance on the Delta and improve regional self-reliance should be reported (1) in the urban and agricultural water management plans; (2) in IRWMPs; and (3) in the California Water Plan. Potential additional measures should be identified and evaluated that will benefit the amount of water, quality of water, and timing of flows in and

through the Delta, and contribute to reduced reliance on the Delta and improving regional self-reliance consistent with Water Code section 85021.

- **Evaluation of urban and agricultural water management plans.** The Council will work with DWR and the State Legislature to identify resources and secure authority, if necessary, to conduct further evaluation of water management information contained in urban and agricultural water management plans. The goal of these actions is to improve knowledge about water management in California and, specifically, to facilitate the aggregation and evaluation of water management data over time to gauge success toward reducing reliance on the Delta, increasing regional self-reliance, and achieving the coequal goals.
- **Integrated water resource management.** The value of integrated regional water management planning is widely recognized, but information on how to implement effective integrated water management projects is not well understood. The number of conjunctive management programs that combine green urban design, flood control, stormwater infiltration, water conservation, recycled water, and groundwater elements are increasing. Information about the successful integration of water management infrastructure needs to be shared and consideration given as to how to effectively promote implementation of these integrated strategies.
- **Agricultural and urban water efficiency.** Improved demand management through urban and agricultural water conservation and efficiency is the fastest and least expensive strategy for making more water available to the Delta through inflows and reducing the pressure to export more water from the Delta. Additional best management practices should be identified and promoted, including evaluation of new water conservation-based rate structures and how they contribute to water savings while maintaining more stable revenue for water suppliers.
- **Delta Watermaster.** The Delta Watermaster is in the process of completing an assessment of potential illegal water diversions within the Delta. This assessment should be expanded to evaluate illegal water diversions throughout the Delta watershed.
- **Reoperation of upstream reservoirs.** DWR is working with USACE and other agencies to develop a coordinated proposal for the reoperation of reservoirs above the Delta to address the impacts of climate change on flood protection and water supply operations. This proposal should include consideration of improved watershed management actions that will also help attenuate flood flows as well as improve ecosystem functions and water supply availability.

Performance Measures

Development of informative and meaningful performance measures is a challenging task that will continue after adoption of the Delta Plan. Performance measures need to be designed to capture important trends and to address whether specific actions are producing expected results. Efforts to develop and track performance measures in complex and large-scale systems like the Delta are commonly multiple-year endeavors. The recommended output and outcome performance measures listed below are provided as examples and subject to refinement as time and resources allow. Final administrative performance measures are listed in Appendix E and will be tracked as soon as the Delta Plan is completed.

Output Performance Measures

- Water suppliers that receive water from the Delta watershed have documented the expected outcome for a measureable reduction in reliance on the Delta and improvement in regional self-reliance. (WR R1, WR R4)
- Progress made in achieving existing water conservation and water supply performance goals, and setting expanded future goals for local, regional, and statewide

water conservation, water use efficiency, and water supply development. (WR R6)

- Information in updated Bulletin 118 is included in the next (2013) California Water Plan Update and in the 2015 urban water management plans and agricultural water management plans. (WR R9)

Outcome Performance Measures

- Progress toward increasing local and regional water supplies, measured by the amount of additional supplies made available (reported in 5-year increments from 2000). (WR P1)
- Progress toward meeting California's conservation goal of achieving a 10 percent reduction in statewide urban per capita water usage by 2015 and a 20 percent reduction by 2020. (WR R1)
- Progress toward improved reliability of Delta water exports and reductions in the vulnerability of Delta exports to disruption. (WR R12, ER P1, RR P1)
- Progress toward increasing the predictability of water deliveries from the Delta in a variety of water year types. (WR R12, WR R14)
- Progress toward achieving California's goal for the increased use of stormwater runoff of at least 500,000 acre-feet per year by 2020 and by at least 1 MAF per year by 2030. (WR R6)

References

ACWA (Association of California Water Agencies). 2011. *Sustainability from the Ground Up, Groundwater Management in California – A Framework*. Sacramento, CA.

AGWA (Association of Groundwater Agencies). 2000. *Groundwater and Surface Water in Southern California: A Guide to Conjunctive Use*. Sacramento, CA.

BDCP (Bay Delta Conservation Plan). 2012a. 2011 Accomplishments. February 2012.

BDCP (Bay Delta Conservation Plan). 2012b. Draft BDCP Chapter 1. February 2012.

BDCP (Bay Delta Conservation Plan). 2012c. *State and Federal Principals Joint Recommendations Regarding Key Elements of the Bay Delta Conservation Plan*. July 16.

California Data Exchange Center. 2011. WSIHIST. Department of Water Resources. Site accessed July 2011. http://cdec.water.ca.gov/cgi-progs/iodir/wsihist.

California Environmental Protection Agency. 2006. Climate Action Team Report to Governor Schwarzenegger and the Legislature. March.

California Natural Resources Agency. 2008. *Managing an Uncertain Future: Climate Change Adaptation Strategies for California's Water*. Sacramento, CA.

California Natural Resources Agency. 2010. *Bay Delta Conservation Plan: Highlights of the BDCP*. Sacramento, CA.

CARB (California Air Resources Board). 2008. *Climate Change Scoping Plan*, Appendices Volume I. 2008. Pursuant to AB 32 The California Global Warming Solutions Act of 2006.

Carlisle, D. M., D. M. Wolock, and M. R. Meador. 2010. "Alteration of streamflow magnitudes and potential ecological consequences: a multiregional assessment." *Frontiers in Ecology and the Environment* 9(5):264-270.

City of Santa Monica. 2012. Sustainable Water Master Plan. http://www01.smgov.net/cityclerk/council/agendas/2011/20110308/s2011030804-A.htm.

Contra Costa Water District. 2011. East Contra Costa County Prop 84 Round 1 Implementation Grant Application.

Dettinger, M. D., F. M. Ralph, T. Das, P. J. Neiman, and D. R. Cayan. 2011. Atmospheric rivers, floods, and the water resources of California. *Water* 3(2):445-478.

DWR (California Department of Water Resources). 2003a. *California's Groundwater*. Bulletin 118, Update 2003. Sacramento, CA.

DWR (California Department of Water Resources). 2003b. Policy 03-10, Principles Regarding Public Participation Process in SWP Contract Negotiations. Sacramento, CA.

DWR (California Department of Water Resources). 2005. *California Water Plan Update 2005*. Sacramento, CA.

DWR (California Department of Water Resources). 2006. Summary of the Status of 2005 Urban Water Management Plans. Prepared by Dave Todd, Chief, Technical Assistance and Outreach Branch. Submitted to the Legislature pursuant to Section 10644(b) of the California Water Code. December 31.

DWR (California Department of Water Resources). 2007a. Status and Trends of Delta-Suisun Services. May.

DWR (California Department of Water Resources). 2008. *Management of the California State Water Project*, Bulletin 132-07. Page xxvii, 150.

DWR (California Department of Water Resources). 2009. *California Water Plan Update 2009*. Sacramento, CA. http://www.waterplan.water.ca.gov/cwpu2009/index.cfm.

DWR (California Department of Water Resources). 2010a. *CALFED Surface Storage Investigations Progress Report*. Sacramento, CA.

DWR (California Department of Water Resources). 2010b. *The State Water Project Delivery Reliability Report, 2009*. Sacramento, CA.

DWR (California Department of Water Resources). 2010c. Proposition 84 and Proposition 1E, Integrated Regional Water Management (IRWM) Grant Program Guidelines for IRWM Implementation and Planning Grants, and Addendum to the IRWM Implementation Grant Round 1. Division of Integrated Regional Water Management. August.

DWR (California Department of Water Resources). 2010d. *Climate Change Characterization and Analysis in California Water Resources Planning Studies*, Final Report. December.

DWR (California Department of Water Resources), SWRCB (State Water Resources Control Board), California Bay-Delta Authority, California Energy Commission, California Department of Public Health, California Public Utilities Commission, and California Air Resources Board. 2010. *20 X 2020 Water Conservation Plan*. With assistance from California Urban Water Conservation Council and Bureau of Reclamation. February.

DWR (California Department of Water Resources). 2011a. Division of Safety of Dams. Site accessed July 2011. http://www.water.ca.gov/damsafety/damlisting/index.cfm.

DWR (California Department of Water Resources). 2011b. Comments on the Fourth Staff Draft Delta Plan dated June 13, 2011. Dale Hoffman-Floerke, DWR, to Joe Grindstaff, Delta Stewardship Council. June 24.

DWR (California Department of Water Resources). 2011c. *The State Water Project Draft Delivery Reliability Report*.

DWR (California Department of Water Resources). 2012a. Dayflow data. Site accessed 2012. http://www.water.ca.gov/dayflow.

DWR (California Department of Water Resources). 2012b. A Summary of 2010 Legislative Report on the Status of the 2010 Urban Water Management Plans. April.

Famiglietti, J. S., M. Lo, S. L. Lo, J. Bethune, K. J. Anderson, T. H. Syed, S. C. Swenson, C. R. de Linage, and M. Rodell. 2011. Satellites measure recent rates of groundwater depletion in California's Central Valley. *Geophysical Research Letters* Vol. 38, L03403.

Faunt, C. C., editor. 2009. *Groundwater Availability of the Central Valley Aquifer, California*. U.S. Geological Survey Professional Paper 1766.

Grimaldo, L. F., T. Sommer, N. V. Ark, G. Jones, E. Holland, P. B. Moyle, B. Herbold, and P. Smith. 2009. Factors affecting fish entrainment into massive water diversions in a tidal freshwater estuary: can fish losses be managed? *North American Journal of Fisheries Management* 29:1253-1270.

Hanak, E., J. Lund, A. Dinar, B. Gray, R. Howitt, J. Mount, P. Moyle, and B. Thompson. 2011. *Managing California's Water: From Conflict to Reconciliation*. San Francisco, CA. Public Policy Institute of California.

Knowles, N. and D. Cayan. 2004. Elevational dependence of projected hydrologic changes in the San Francisco estuary and watershed. *Climatic Change* 62:319-336.

Knowles, N., Dettinger, M., and Cayan, D. 2006. Trends in snowfall versus rainfall for the Western United States. *Journal of Climate* 19(18):4545-4559.

LADWP (Los Angeles Department of Water and Power) 2012. "LADWP Reminds Customers to Conserve Water: Reduced Snowpack and Increased Water Use Call for Increased Conservation." May 8.

LAEDC (Los Angeles Economic Development Corporation). 2008. *Where Will We Get the Water? Assessing Southern California's Future Water Strategies*.

LAO (California Legislative Analyst's Office). 2008. *California's Water: An LAO Primer*. October 22.

LAO (California Legislative Analyst's Office). 2009. *Resources and Environmental Protection*. 2009 – 10 Budget Analysis Series. February 3.

LAO (California Legislative Analyst's Office). 2011. Cal Facts. http://www.lao.ca.gov/reports/2011/calfacts/calfacts_010511.aspx

Littleworth, Arthur, and E. L. Garner. 2007. *California Water II*. (2nd edition). Solano Press Books.

MMWD (Marin Municipal Water District). 2010. http://www.marinwater.org/documents/2010_uwmp_mmwd.

Nelson, Rebecca. 2011. *Uncommon Innovation: Developments in Groundwater Management Planning in California*. The Woods Institute for the Environment/The Bill Lane Center for the American West. Palo Alto, CA.

NRC (National Research Council of the National Academies). 2012. *Sustainable Water and Environmental Management in the California Bay-Delta*. Washington D.C. http://www.nap.edu/catalog.php?record_id=13394.

Null, S. E., J. H. Viers, J. F. Mount. 2010. Hydrologic response and watershed sensitivity to climate warming in California's Sierra Nevada. *PLoS ONE* 5(4).10.1371/journal.pone.0009932.

OPC (California Ocean Protection Council). 2011. *Resolution of the California Ocean Protection Council on Sea-Level Rise*. March. http://www.opc.ca.gov/webmaster/ftp/pdf/docs/ OPC_SeaLevelRise_Resolution_Adopted031111.pdf.

Reclamation (Bureau of Reclamation). 2011a. SECURE Water Act Section 9503(c). Reclamation Climate Change and Water. Report to Congress. April.

Reclamation (Bureau of Reclamation). 2011b. 3404(c) CVPIA Contract Renewal Process. Site accessed April 21, 2011. http://www.usbr.gov/mp/cvpia/3404c/index.html.

Reclamation (Bureau of Reclamation). 2011c. Summary of water supply allocations. Site accessed 2012. http://www.usbr.gov/mp/cvo/vungvari/water_allocations_historical.pdf.

Regional Water Authority. 2011. *American River Basin IRWM Implementation Program*. January.

RMC Water and Environment. 2011. *2010 Urban Water Management Plan*. Prepared for West Basin Municipal Water District. May.

Robie, Ronald B. 2012. Effective implementation of the Public Trust Doctrine in California water resources decision-making: A view from the bench. 45 U.C. Davis L. Rev. 1155, 1176.

San Francisco Public Utilities Commission. 2011. *2010 Urban Water Management Plan for the City and County of San Francisco*. June.

Semitropic Water Storage District. 2011. *Poso Creek IRWMP Implementation Grant Proposal*. January.

SWRCB (State Water Resources Control Board). 2008. State Water Resources Control Board and Regional Water Quality Control Board (Water Boards) Response to Second Round of Delta Vision Questions. Letter to Delta Vision Task Force, June 12, 2008.

SWRCB (State Water Resources Control Board). 2009. Legislative Report. Coordinated Water Measurement Data Base: Developed Pursuant to the Requirements of Chapter 675, Statutes of 2007. May 2009.

SWRCB (State Water Resources Control Board). 2010. Development of Flow Criteria for the Sacramento-San Joaquin Delta Ecosystem. August 3. http://www.waterboards.ca.gov/waterrights/ water_issues/programs/bay_delta/deltaflow/docs/final_rpt080310.pdf.

SWRCB (State Water Resources Control Board). 2011. Email from Tom Howard to Joe Grindstaff, responding to request for information pertaining to the allocation of water in California and the Delta watershed, prepared by SWRCB staff. August 9.

USEPA and DWR (U.S. Environmental Protection Agency, Region 9, and California Department of Water Resources). 2011. *Climate Change Handbook for Regional Water Planning*. In partnership with U.S. Army Corps of Engineers South Pacific Division, Resources Legacy Fund and U.S. EPA Office of Research and Development. November 2011.

USGS (U.S. Geological Survey). 2010. *Water Data Report 2010*.

WBMWD (West Basin Municipal Water District). 2010. Urban Water Management Plan. http://www.westbasin.org/files/uwmp

Western Regional Climate Center. 2011a. California climate tracker database query. Statewide annual precipitation by water year from 1896-2010. Site accessed July 2011. http://www.wrcc.dri.edu/monitor/cal-mon/ frames_version.html.

Western Regional Climate Center. 2011b. Climate of California. National Oceanic and Atmospheric Administration Narrative Summaries, Tables, and Maps for Each State with Overview of State Climatologist Programs, 3rd ed., Vol. 1. Site accessed July 2011. http://www.wrcc.dri.edu/narratives/CALIFORNIA.htm.

Willis, A. D., J. R. Lund, E. S. Townsley, and B. A. Faber. 2011. Climate change and flood operations in the Sacramento Basin, California. *San Francisco Estuary and Watershed Science* 9(2).

Zone 7. 2010. Zone 7 Water Agency. 2010 Urban Water Management Plan. December 15, 2010.

Photo Credits

Chapter divider *(clockwise from top left)***:** California Department of Water Resources, Dale Kolke/Kimberly Wong, and California Department of Water Resources.

Page 69: California Department of Water Resources

Page 93: California Department of Water Resources

CHAPTER 4

Protect, Restore, and Enhance the Delta Ecosystem

ABOUT THIS CHAPTER

This chapter describes the Sacramento-San Joaquin Delta (Delta) ecosystem and the factors that affect and too often degrade it. It proposes policies and recommendations for restoring the Delta ecosystem organized into five core strategies to achieve the coequal goals of the Delta Reform Act:

- Create more natural functional flows
- Restore habitat
- Improve water quality to protect the ecosystem
- Prevent introduction of and manage nonnative species impacts
- Improve hatcheries and harvest management

These core strategies form the basis of the five policies and nine recommendations found at the end of the chapter.

RELEVANT LEGISLATION

The coequal goals for the Delta (Water Code section 85054) are relevant to ecosystem restoration:

> *"Coequal goals" means the two goals of providing a more reliable water supply for California and protecting, restoring, and enhancing the Delta ecosystem. The coequal goals shall be achieved in a manner that protects and enhances the unique cultural, recreational, natural resource, and agricultural values of the Delta as an evolving place.*

Eight objectives in Water Code section 85020 are inherent in the coequal goals. Section 85020(a), (c), and (e) are relevant to this chapter:

> *85020 The policy of the State of California is to achieve the following objectives that the Legislature declares are inherent in the coequal goals for management of the Delta:*
>
> > *(a) Manage the Delta's water and environmental resources and the water resources of the state over the long term.*
> >
> > *(c) Restore the Delta ecosystem, including its fisheries and wildlife, as the heart of a healthy estuary and wetland ecosystem.*
> >
> > *(e) Improve water quality to protect human health and the environment consistent with achieving water quality objectives in the Delta.*

The coequal goals and inherent objectives seek broad protection of the Delta. Achievement of these broad goals and objectives requires implementation of specific strategies. Water Code sections 85022 and 85302 provide direction on the implementation of specific measures to promote the coequal goals and inherent objectives related to the Delta ecosystem restoration.

> *85022(d)(5) Develop new or improved aquatic and terrestrial habitat and protect existing habitats to advance the goal of restoring and enhancing the Delta ecosystem.*
>
> > *(6) Improve water quality to protect human health and the environment consistent with achieving water quality objectives in the Delta.*

85302(c) The Delta Plan shall include measures that promote all of the following characteristics of a healthy Delta ecosystem.

> *(1) Viable populations of native resident and migratory species.*
>
> *(2) Functional corridors for migratory species.*
>
> *(3) Diverse and biologically appropriate habitats and ecosystem processes.*
>
> *(4) Reduced threats and stresses on the Delta ecosystem.*
>
> *(5) Conditions conducive to meeting or exceeding the goals in existing species recovery plans and state and federal goals with respect to doubling salmon populations.*

85302(d) The Delta Plan shall include measures to promote a more reliable water supply that address all of the following:

> *(1) Meeting the needs for reasonable and beneficial uses of water.*
>
> *(3) Improving water quality to protect human health and the environment.*

85302(e) The following subgoals and strategies for restoring a healthy ecosystem shall be included in the Delta Plan.

> *(1) Restore large areas of interconnected habitats within the Delta and its watershed by 2100.*
>
> *(2) Establish migratory corridors for fish, birds, and other animals along selected Delta river channels.*
>
> *(3) Promote self-sustaining, diverse populations of native and valued species by reducing the risk of take and harm from invasive species.*
>
> *(4) Restore Delta flows and channels to support a healthy estuary and other ecosystems.*
>
> *(5) Improve water quality to meet drinking water, agriculture, and ecosystem long-term goals.*
>
> *(6) Restore habitat necessary to avoid a net loss of migratory bird habitat and, where feasible, increase migratory bird habitat to promote viable populations of migratory birds.*

This page intentionally left blank.

CHAPTER 4

Protect, Restore, and Enhance the Delta Ecosystem

In the Delta Reform Act, the goal of protecting, restoring, and enhancing the Delta ecosystem is coequal to the goal of providing a more reliable water supply for California. Both must be accomplished while protecting and enhancing the unique cultural, recreational, natural resource, and agricultural values of the Delta as an evolving place.

Some past land and water uses have put these goals in conflict. For example, reliable water supplies have been associated with artificially stabilized flows and a complex human-made system of infrastructure that includes dams, levees, and channelized rivers and sloughs. Yet healthy rivers and estuaries, and the native species that live in them depend on naturally variable water flows and a dynamic landscape. Many native species also depend on wetlands that have been drained for farming and other human uses.

Despite these conflicts, the Delta Stewardship Council (Council) must work to achieve the goal of protecting, restoring, and enhancing the Delta ecosystem. Inherent in that goal is the objective to "restore the Delta ecosystem, including its fisheries and wildlife, as the heart of a healthy estuary and wetland ecosystem" (Water Code section 85020(c)). (See sidebar, What Does It Mean to Achieve the Goal of Protecting, Restoring, and Enhancing the Delta Ecosystem?)

The Council envisions a future in which the Delta ecosystem has the following characteristics:

- Native species, including algae and other plants, invertebrates, fish, birds, and other wildlife, are self-sustaining and persistent.
- The tidal channels and bays in the Delta and Suisun Marsh connect with freshwater creeks, upland grasslands, and woodlands.
- The Sacramento and San Joaquin rivers and other Delta tributaries include reaches where streams are free to meander and connect seasonally to functional floodplains.
- Habitats for resident and rearing migratory fish, birds, and upland wildlife are connected by migratory corridors, including areas with high-quality cover and feeding opportunities.
- More natural variations in water flows and conditions make aquatic habitats, tidal marshes, and floodplains more dynamic, encourage survival of native species, and resist invasions by weeds and animal pests.
- The ecosystem is resilient enough to absorb and adapt to current and future effects of multiple stressors without significant declines in ecosystem services.
- The Delta will provide more reliable water supplies, in part because survival of its wildlife, fish, and plants do not require extraordinary regulatory protection.
- Californians recognize and celebrate the Delta's unique natural resource values through wildlife observation, angling, waterfowl hunting, and other outdoor recreation.

This future Delta will differ from the Delta that greeted the first Californians and will probably be different from the current ecosystem. Not every species or natural area now found in the Delta may persist through the changes ahead, including climate change, but Californians' use and management of the Delta will be directed and coordinated to sustain conditions that make species' survival more likely while maintaining the many other benefits provided by the Delta ecosystem.

WHAT DOES IT MEAN TO ACHIEVE THE GOAL OF PROTECTING, RESTORING, AND ENHANCING THE DELTA ECOSYSTEM?

Achieving the coequal goal of ecosystem protection, restoration, and enhancement means successfully establishing a resilient, functioning estuary and surrounding terrestrial landscape capable of supporting viable populations of native resident and migratory species with diverse and biologically appropriate habitats, functional corridors, and ecosystem processes.

For this purpose, the term "restoration" is defined in Water Code section 85066 as follows:

> *"the application of ecological principles to restore a degraded or fragmented ecosystem and return it to a condition in which its biological and structural components achieve a close approximation of its natural potential, taking into consideration the physical changes that have occurred in the past and the future impact of climate change and sea level rise."*

Restoration actions may include restoring interconnected habitats within the Delta and its watershed, restoring more natural Delta flows, or improving ecosystem water quality.

"Protection" means preventing harm to the ecosystem, which could include preventing the conversion of existing habitat, the degradation of water quality, irretrievable conversion of lands suitable for restoration, or the spread of invasive nonnative species.

"Enhancement" means improving existing desirable habitat and natural processes. Enhancement might include flooding the Yolo Bypass more often to support native species, or to expand or better connect existing habitat areas. Enhancement includes many fish and wildlife management practices, such as managing wetlands for waterfowl production or shorebird habitat, installing fish screens to reduce entrainment of fish at water diversions, or removing barriers that block migration of fish to upstream spawning habitats.

DP-306

A Restored Delta Ecosystem Is Key to a Reliable Water Supply

Delta water supplies can be more reliable only when the Delta ecosystem is restored. The water projects that rely on the Delta were developed without contemporary understanding of the Delta's ecology or anticipation of the value that Californians now place on a healthy environment. As the effects of the projects on the Delta ecosystem became apparent, a series of adjustments in their operation has been put in place. Each adjustment affected the water diversions, altering volume and timing to reduce damage, but without fully mitigating harm to the Delta ecosystem. The perilous condition of salmon, delta smelt, and other species remains a key limit on project operations. Only as these populations recover will water project operations become more flexible and reliable.

To restore the Delta ecosystem, Californians will need to use water management facilities in new ways. Reservoirs will need to hold and release water for ecosystem purposes as well as for water users. Storage and the development of alternative supplies will be needed to help reduce reliance on the Delta and improve regional self-reliance. Multipurpose bypasses and levees will need to provide habitat while also controlling flooding. Channels and water controls will need to be able to deliver water for habitats as well as for farms and cities. Modern water diversions will need to protect fish while providing reliable water supplies. For these reasons, restoring the Delta ecosystem will require new investment in water facilities and alternative supplies, not just regulation of water project operations or restoration of habitats for fish and wildlife. Other actions undertaken to protect the ecosystem can also benefit water users; for example, vigilance in preventing invasive species introduction can avoid future costs to manage mussel infestations in pipelines or other water structures. Tradeoffs may be necessary as we better match demands to the supply available, consistent with ecosystem protection, and match our expectations about the ecosystem to the changing climate.

A restored Delta ecosystem is also important to the Delta's future as an attractive place to live, work, and recreate. Water flows are important not just to water exporters, fish, and aquatic environments, but also to the Delta's municipal, industrial, and agricultural waters users, who will need consideration as system changes are planned and implemented. Restoration actions will require careful design so they are attuned to local needs: locating habitats to minimize conflicts with existing and planned uses; working with farmers by promoting wildlife-friendly farming; providing buffers between wildlife areas and farms; working with landowners regarding how to manage restored wildlife populations on or near their lands; and improving opportunities for outdoor recreation, including boating, angling, and hunting, that are enjoyed by residents and also attract visitors. Integrating habitat improvements when levees are rebuilt or flood channels are improved can draw new sources of funds to strengthen the Delta flood control system. In essence, a systems approach that recognizes tradeoffs and the value of balance will be necessary for California to achieve the coequal goals.

The Delta Ecosystem, Past and Present

In the Delta, the Central Valley's great rivers—the Sacramento from the north and San Joaquin from the south—join the Cosumnes, Mokelumne, and Calaveras here in a vast and complex estuary influenced by tides and river currents (see Figure 4-1).

Before the early 1800s, the rivers flowed through approximately 400,000 acres of tidal wetlands and other aquatic habitats that connected with several hundred thousand acres of nontidal wetlands and riparian forest. Flows of the Delta's rivers and tidal channels varied by season and year-to-year, sometimes pouring from the Sierra in great floods whose fresh waters overflowed wetlands and floodplains, and at other times declining as droughts shriveled rivers and brackish tidewaters pushed inland. To the west, the rivers joined to discharge through marsh-fringed Suisun Bay to the Carquinez Straight, San Francisco Bay, and the Pacific Ocean.

The Delta's historical landscape also varied from north to south (see Figure 4-2). In the north Delta, flood basins occurred where the Sacramento River intertwined with tidal channels. A vast area of freshwater wetlands dominated by tules transitioned into tidal wetlands. Shallow perennial ponds and lakes, broad riparian forests along natural levees, and seasonal wetlands at the upland edge were also common. The central Delta was characterized by large, tidal islands that flooded during spring tides (or more frequently) intersected by networks of branching tidal channels. Channel banks were low and covered by the willows, grasses, sedges, shrubs, and ferns that also grew in island interiors. The south Delta contained a complex network of channels formed predominantly by riverine processes. The floodplain comprised emergent wetlands, perennial and seasonal ponds, willow thickets, and seasonal wetlands. Driftwood and other woody debris filled some channels, likely from riparian forest along the San Joaquin River's natural levees.

Historical records show a rich and complex Delta with habitats supporting diverse and abundant native plants and animals (Grossinger et al. 2010, Whipple et al. 2010, Whipple 2011). Some fish, including smelt, schooled in the open waters of the western Delta's bays and channels, moving east when brackish water intruded from San Francisco Bay. Other resident wildlife and plants also prospered: rails in tidal and tule marshes, giant garter snakes in freshwater wetlands and ponds, and riparian brush rabbits and wood rats in willow thickets and riparian forests. Each fall, salmon and steelhead, drawn by the swelling Sacramento and San Joaquin rivers, migrated inland from the ocean and navigated upstream to spawning areas in their tributaries. As river flows receded, their young, emerging from these tributaries' spawning gravel, would return downstream and shelter in driftwood-lined eddies or undercut riverbanks and feed in Delta sloughs, marshes, and floodplains before returning to the sea. Waterfowl, cranes, and shorebirds migrated through the Delta along a north-south route that stretched from the Arctic to Mexico or beyond. Songbirds followed a similar path through riparian woodlands that connected from the Sacramento Valley through the Delta to the San Joaquin Valley.

To immigrants arriving in the nineteenth century, the Delta and Central Valley appeared a wild and dangerous place that had to be "reclaimed" to support the agricultural way of life they had inherited from their ancestors. The rapid transformation of the historical Delta over 160 years involved many changes. Over 1,000 miles of levees were constructed to drain wetlands and protect islands from damaging floods. Channels were cut between sloughs or through islands to ease navigation and encourage drainage without regard to effects on the estuary. Forests were cut and land leveled for farming (Hanak et al. 2011). This transformation produced the rich agricultural economy and rural culture of the Delta described in Chapter 5. But it came at a cost: loss of the original estuarine ecosystem and its species, and native people.

Comparison of Historical (early 1800s) and Modern Delta Waterways

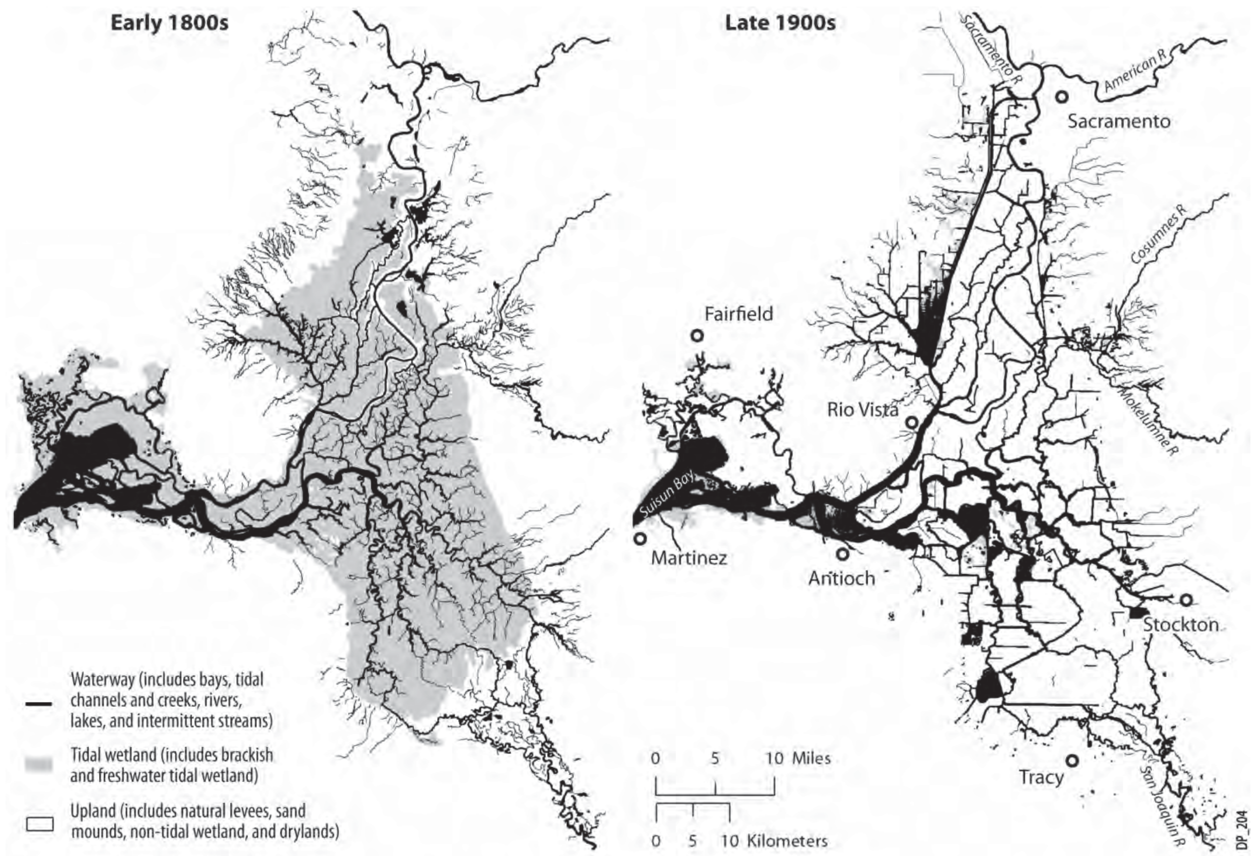


Figure 4-1 The map at left shows the complexity of early 1800s Delta hydrography (black) within tidal wetland (gray). The modern hydrography at right shows major differences such as channel widening, meander cuts, cross levees, and loss of within-island channel networks and tidal wetland.

Source: San Francisco Estuary Institute 2012

Primary Landscapes in the Historical Delta

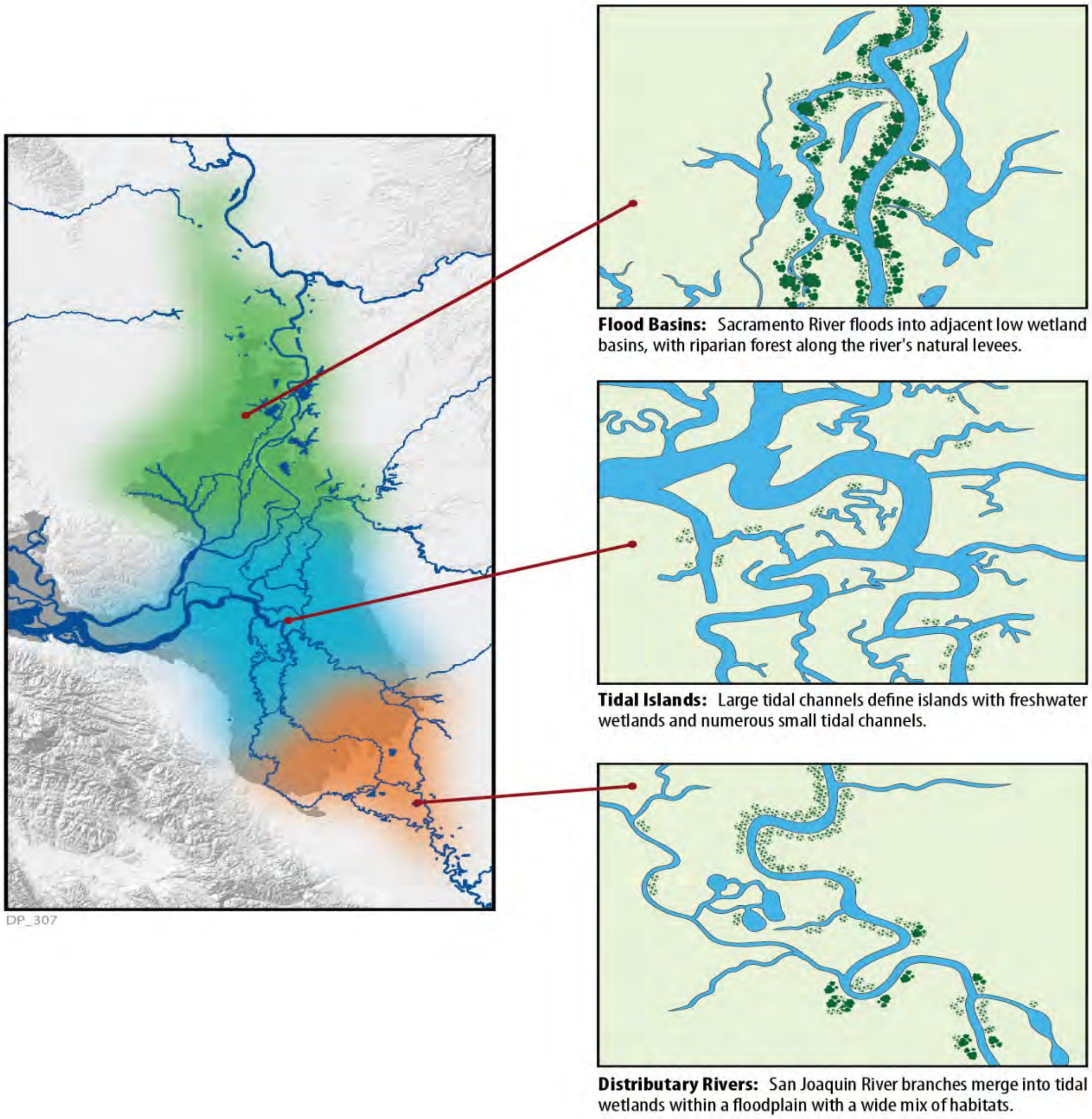


Figure 4-2

The historical Delta can be divided into three primary landscapes: flood basins in the north Delta, tidal islands in the central Delta, and distributary rivers (rivers with multiple branches flowing away from main channels) in the south Delta. Transitions between these landscapes occurred gradually, across broad areas. Though these landscapes held many habitat types in common, characteristics and spatial patterns varied greatly—these large-scale patterns are what helped define the landscapes, which in turn provided different functions for native species. Understanding these major landscape types is a valuable framework for evaluating current and future restoration strategies in the Delta, providing a baseline between the current landscapes and the long-established historical patterns.

Source: Whipple 2011

Nearly all the rivers historically flowing to the Delta were dammed, creating Shasta, Folsom, Millerton, and Oroville lakes and other impoundments described in Chapter 3. These dams, together with levees constructed to prevent flooding, blocked access to spawning areas and other habitats critical to salmon, splittail, and other fish. The once pronounced seasonal and year-to-year variability of river flows has given way to more stable, artificially regulated conditions. The formerly complex Delta sloughs have been replaced by a simplified grid of straightened channels, cuts, and often rock-lined rivers fixed in space and time, and used for water conveyance and shipping. Pumps to divert water for irrigation or municipal use south or west of the Delta further disrupted the estuary (see Figure 4-3).

Ecosystem restoration cannot restore the historical Delta. Its alteration is too complete to reverse and could not occur without damage to other beneficial uses of its water and land. The Delta Reform Act recognizes these limitations and defines restoration as a "...close approximation of its natural potential..." (Water Code section 85066).

Ecosystem Stressors

Many factors stress the Delta's ecosystem (Baxter et al. 2010). Stressors are actions or factors, whether caused by humans or nature, that negatively affect the ecosystem processes and functions. Stressors include altered flows, habitat loss, entrainment in Delta diversions, degraded water quality, harmful nonnative species, migration barriers, and impacts from hatcheries. Reducing one stressor, or even several stressors, is unlikely to solve all environmental problems in the Delta (Delta ISB 2011, see Appendix I). Many restoration projects fail because multiple stressors have been insufficiently considered (Palmer et al. 2005). Because of uncertainty over cause and effect, ecosystem restoration must address as many stressors as possible through adaptive management, as described in Chapter 2 and Appendix C.

Organizing stressors into categories, such as those developed by the Delta Independent Science Board (ISB), helps resource managers to think about, assess, and manage them. (See sidebar, Stressor Categories to Help with Management Options.) Ecosystem stressors and their effects can be categorized by what causes them (sources of stress) or by what can be done about them. The Delta Plan's ecosystem restoration strategies address the following current stressors:

- Delta flows
- Habitat
- Ecosystem water quality
- Nonnative species
- Hatcheries and harvest management

STRESSOR CATEGORIES TO HELP WITH MANAGEMENT OPTIONS

The Delta ISB developed categories that put Delta stressors into broad context to help assess management options (for example, what can be done about them) (Delta ISB 2011). Management options are stressor reduction, elimination, or mitigation. When this is not possible, adaptation to stressors must be promoted. The Delta ISB has proposed the following categories:

- **Current stressors** result from ongoing human activities that at least in some cases can be eliminated (for example, fish entrainment at water diversions and pollution from point sources).
- **Legacy stressors** result from past actions that cannot be undone, but their impact can sometimes be reduced or mitigated (for example, mercury pollution from historical gold mining and past introductions of nonnative species).
- **Globally determined stressors** result from large-scale human activities or natural processes that cannot be eliminated or mitigated within the purview of the Delta Plan and require larger-scale planning and adaptation (for example, global climate change and human population growth).
- **Anticipated future stressors** require preparation (for example, future land subsidence, urban expansion, and new invasions by nonnative species).

These categories have some overlap; for example, a globally determined stressor such as sea level rise also can be an anticipated future stressor.

DP-317

Changes in Historical Flows Challenge Delta Ecology

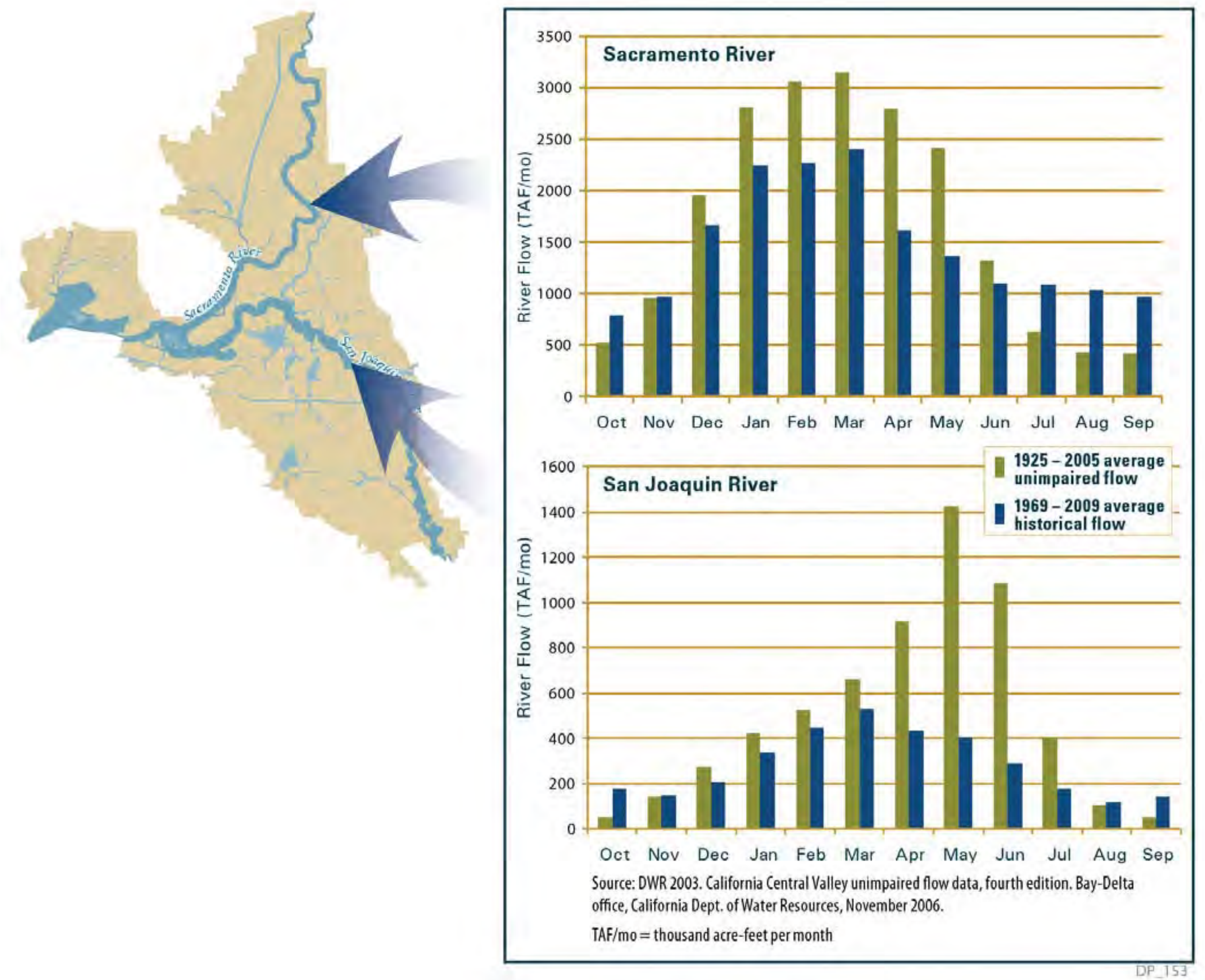


Figure 4-3

Habitat for native species has been shaped in the past by natural cycles of river flows.* Since the 1960s, our water system, with its upstream reservoirs, diversions, and other management facilities, has changed these patterns in two ways. First, seasonal flows are much less variable and encourage nonnative fish and vegetation, which can crowd out native species that thrive in a more varied environment. Second, peak flows now come at lower magnitudes and occur earlier on the San Joaquin; this shift affects water temperatures, salinity, and access to habitat, causing stress on native species.

** Natural flow is runoff that would have occurred had the landscape and waterways remained unaltered. Our best estimate of natural Delta inflow is "unimpaired flow," the flow that would be expected if reservoirs were removed but the contemporary watershed and valley land uses remained. However, natural and unimpaired Delta inflow are not the same, and the difference between them could be substantial at times.*

Climate Change

Climate change will cause major stresses on the Delta ecosystem. Rising sea level could inundate freshwater marshes and other freshwater aquatic habitats, potentially with brackish water, reducing habitat for native plants, fish, and wildlife. In addition to rising sea level, the amount of ideal low-salinity habitat for native fish such as the delta smelt will be affected by changes in runoff timing and intensity, which will also affect erosion and sedimentation patterns, again altering fish habitat. Increased water temperature will negatively affect smelt, salmon, and other coldwater-dependent fish, and will likely increase the range of invasive species (Healey et al. 2008, Villamanga and Murphy 2010). In terrestrial habitats, warming could create soil moisture deficits, change plant community composition, and even disrupt timing between pollinators and plants (California Natural Resource Agency 2009). Overall climate change will exacerbate current challenges to the protection and restoration of Delta ecosystems.

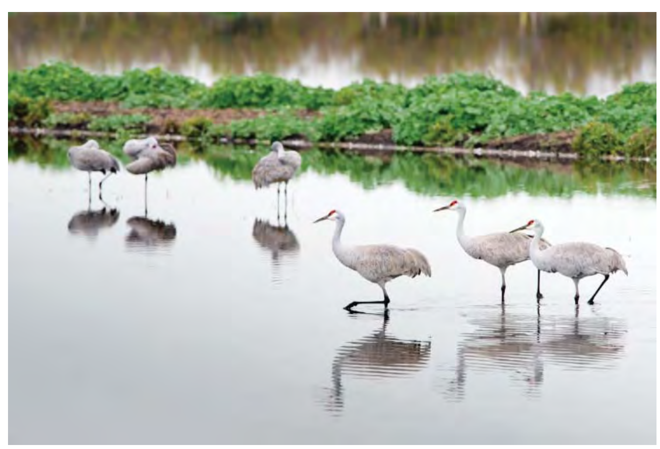
Ecosystem Restoration

Restoration of the Delta ecosystem does not mean a return to predevelopment conditions with only its native plants and animals. That is beyond human ability. Instead, restoration seeks to return areas to a close approximation of their natural potential, including re-establishing natural habitat and ecosystem functions, as feasible, within the context of the current configuration of the Delta, the current biological communities, and the permanent modifications to Delta land forms and hydrology. Successful ecosystem restoration rehabilitates key elements—the living and nonliving features such as soils, elevation, waterways, species, populations, and habitats—and the structure and processes that connect them. This section summarizes the principles of and considerations for ecosystem restoration in the Delta.

Much work has been done to develop ecological principles specific to the Delta. (See sidebar, Delta Ecological Principles.) Restoration projects that adhere to these principles are more likely to achieve their goals and objectives.

The Delta Reform Act's definition of restoration recognizes that the ecosystem will be dynamic, changing in response to restoration actions and future climate change (Healey et al. 2008, Delta ISB 2011). The desired future condition is an evolving ecosystem that supports communities of both native and nonnative species, and continues to provide value such as clean water, flood storage, or recreational fishing. A dynamic, restored Delta ecosystem can be a natural complement to the Delta as an "evolving place" described in Chapter 5.

To increase the likelihood of ecosystem restoration success, plans and actions must incorporate the principles of adaptive management (see Chapter 2 and Appendix C for a detailed discussion). This begins with a clear, practical vision of what will be achieved for the ecosystem, together with human need for water supply reliability and flood risk reduction. Additional examples are provided in the sidebar, Current Delta Ecosystem Restoration Efforts.



DELTA ECOLOGICAL PRINCIPLES

The following are ecological principles for the Delta adapted from those developed for the Delta Vision Blue Ribbon Task Force by former CALFED Lead Scientist Michael Healey (2007a, 2007b) and for the Bay Delta Conservation Plan (BDCP) Steering Committee by the BDCP Independent Science Advisors (2007).

Principle 1: Humans are part of the Delta ecosystem. Human activities over the past 160 years have produced a Delta ecosystem that is different from the historical ecosystem, and will remain so even as human-induced stressors are modified.

Management implications: Strategic management of human activities, and uses of the landscape and water in the Delta will be integral to the successful protection, restoration, and enhancement of the Delta ecosystem.

Principle 2: The Delta ecosystem is part of larger ecosystems. The Delta ecosystem affects and is affected by surrounding ecosystems. High year-to-year variability in precipitation and river flows are, in part, caused by climate patterns that span the entire Pacific Ocean. In addition, many animals that use the Delta do so for only part of their life cycles, spending other parts upstream in the rivers, in the ocean, or as far as away as South America and northern Canada.

Management implication: Management of the Delta cannot occur independently of structures and events upstream and in the ocean, in regional and state economies, or in the wider governance context.

Principle 3: The Delta ecosystem is a mosaic of smaller terrestrial and aquatic ecosystems. These ecosystems interact in important ways (for example, exchange of material, energy, and species). This landscape mosaic determines overall performance of the ecosystem. The size, shape, arrangement, and connections within the mosaic are critical to the way the Delta functions.

Management implication: Management plans and decisions need to be informed by a landscape perspective that recognizes interrelationships among patterns of land and water use, patch size, location and connectivity, and species success. The landscape perspective needs to be developed at several physical and temporal scales.

Principle 4: The Delta ecosystem is naturally dynamic. This includes disturbances and extreme events such as very wet and very dry years. Changes in one part of the Delta may have far-reaching effects in space and time.

Management implication: The Delta cannot be managed as a homogenous or static system.

Principle 5: Native Delta species are adapted to a naturally dynamic Delta ecosystem. The natural Delta is dynamic and variable, and the organisms living there are adapted to that variability.

Management implication: In order to successfully protect, restore, and enhance the Delta, management needs to include actions that mimic, to some extent, the historical natural variability.

Principle 6: Each native Delta species has particular tolerances for habitat variables such as temperature, dissolved oxygen, salinity, turbidity, and toxic substances. Species distributions may shift if conditions change and exceed these tolerances. Increase of air and water temperature by even 2 degrees may make the Delta uninhabitable for some local species and also make it potentially inhabitable for species from warmer regions.

Management implication: Loss of some species from the ecosystem may be inevitable. For local species, refugia may have to be located in cooler regions if extinction is to be prevented. Additional actions may be necessary to alleviate a potential increase in nonnative invasive species.

DP-308

CURRENT DELTA ECOSYSTEM RESTORATION EFFORTS

Several significant ecosystem restoration planning and implementation efforts are worth noting:

- The draft Ecosystem Restoration Program (ERP) Conservation Strategy was released by the California Department of Fish and Wildlife (DFW) in 2011 (DFG 2011) to update the CALFED ERP plans from 2000. DFW collaborates with its federal fish agency partners, the U.S. Fish and Wildlife Service and National Marine Fisheries Service, to implement the ERP, including providing grants for Delta and Suisun Marsh restoration research and implementation.
- DFW and the California Department of Water Resources (DWR) are continuing to implement and plan for ecosystem restoration projects begun under the CALFED Bay-Delta Program located in Suisun Marsh, at Dutch Slough, at Cache Slough, in the Yolo Bypass, and at the Cosumnes Preserve's North Delta project.
- The *Suisun Marsh Habitat Management, Preservation, and Restoration Plan* is a comprehensive approach to restoring 5,000 to 7,000 acres of tidal wetlands and maintaining managed wetlands and their functions consistent with the CALFED program, the Suisun Marsh Preservation Agreement, applicable species recovery plans, and other interagency goals.
- The Bay Delta Conservation Plan (BDCP) is an overarching approach to large-scale ecosystem restoration now in the planning process (see sidebar, Bay Delta Conservation Plan and Delta Ecosystem Restoration).
- Several Habitat Conservation Plans (HCP) and Natural Community Conservation Plans (NCCP) for parts of the Delta are in place or under development in the Delta. These plans' purpose is to minimize and mitigate the impact of authorized incidental take of the endangered or rare species and their habitats. Completed HCPs and NCCPs in the Delta include the San Joaquin HCP and East Contra Costa County HCP/NCCP. The BDCP, Yolo County HCP/NCCP, South Sacramento HCP, and Solano Multispecies HCP are under development.
- The State Water Resources Control Board (SWRCB) is updating its Bay-Delta Water Quality Control Plan (Bay-Delta Plan). The first phase focuses on objectives to protect water quality for south Delta agriculture and San Joaquin River flow objectives to protect fish and wildlife. The second phase focuses on other changes to its Bay-Delta Plan to protect fish and wildlife, including Delta outflow objectives, Sacramento River flow objectives, export/inflow objectives, Delta Cross Channel Gate closure objectives, Suisun Marsh objectives, potential new reverse flow objectives for Old and Middle rivers, potential new floodplain habitat flow objectives, potential changes to the monitoring and special studies program, other potential changes to the program of implementation, and issues identified through the BDCP process. As part of the SWRCB's review of its Bay-Delta Plan, it will consider information developed as part of its 2010 staff technical report *Development of Flow Criteria for the Sacramento–San Joaquin Delta Ecosystem* (SWRCB 2010) along with information about other factors, such as coldwater pool requirements and other water uses.
- In 2009, the Legislature established the Sacramento–San Joaquin Delta Conservancy (Delta Conservancy) as a primary State agency to implement ecosystem restoration in the Delta, along with supporting efforts that advance environmental protection and the economic well-being of Delta residents. The Delta Conservancy adopted a strategic plan to guide its planning and implementation efforts in March 2012.
- DWR's Delta Levees Special Flood Control Projects program provides funding to local agencies in the Delta for habitat projects linked to flood management improvements. Similarly, DWR's *2012 Central Valley Flood Protection Plan* proposes new or enhanced flood bypasses, levee setbacks, and fish passage improvements that provide both flood risk reduction and habitat. This effort is discussed in more detail in Chapter 7.

DP-303

Delta Flows

The Delta is the upstream portion of the San Francisco Estuary, where ecosystems dominated by the Central Valley's rivers transition to the more ocean-influenced ecosystem of the downstream portions of the estuary. Water flow is a "master variable," driving the ecological health of rivers and their ability to support valued environmental services (Poff et al. 1997, Postel and Richter 2003). In estuaries, the interaction of river flows and ocean tides produces a salinity gradient from fresh water to brackish and salty water. River flows and ocean tides also deposit and erode sediment to shape the estuarine landscape and its habitats. Estuarine species are adapted to the complex natural flow, salinity, and sediment dynamics in their native estuaries.

Delta flows can be divided into three categories: (1) river and floodplain flows, (2) in-Delta net channel flows, and (3) net Delta outflows (SWRCB 2010). Each category has different ecological effects. (See sidebar, Flow Is More than Just Volume.)

BAY DELTA CONSERVATION PLAN AND DELTA ECOSYSTEM RESTORATION

The parties seeking permits pursuant to the Bay Delta Conservation Plan (BDCP) are attempting to formulate a 50-year plan that, if successful, would ultimately contribute to the recovery of priority species, restoration of a more naturally functioning Delta ecosystem, and establishment of a secure and reliable water supply from the Delta for human use.

As discussed in the Chapter 3 sidebar, BDCP and Water Supply Reliability, the BDCP is a planning process intended to result in the issuance of permits from the California Department of Fish and Wildlife (DFW) under the Natural Community Conservation Planning Act and from the U.S. Fish and Wildlife Service and the National Marine Fisheries Service pursuant to Section 10 of the federal Endangered Species Act (ESA). In addition, the Bureau of Reclamation will use the information developed from this process to obtain incidental take authorization through an ESA Section 7 process. The BDCP proposes to contribute to the restoration of the health of the Delta's ecological systems by contributing to a more natural flow pattern than existing conditions within the Delta and by implementing a comprehensive restoration program.

As currently proposed, the BDCP takes an approach to supporting landscape-level processes by creating a reserve system consisting of a mosaic of natural communities that would be adaptable to changing conditions (including sea level rise) to sustain populations of covered species and maintain or increase native biodiversity (BDCP 2012). The proposal considers protection of at least 31,000 acres of existing natural communities, and restoration or creation of at least 72,809 acres of natural communities, including at least 65,000 acres of tidally influenced natural communities. In addition, the BDCP is intended to improve the Delta ecosystem by taking actions such as:

- Protecting and improving habitat linkages to promote the movement of native species
- Accommodating future sea level rise by providing transitional areas that allow future upslope establishment of tidal wetlands
- Allowing natural flooding to promote the regeneration of vegetation and related ecosystem processes
- Connecting rivers and their floodplains to recharge groundwater, provide fish spawning and rearing habitat, and increase food supply
- Managing the distribution and abundance of nonnative predators to reduce predation on native special-status species

Examples of elements of the BDCP strategy to support natural communities include:

- Controlling invasive nonnative plant species
- Restoring or creating 5,000 acres of riparian forest
- Restoring corridors of riparian vegetation along 20 miles of channel margin
- Restoring 2,000 acres of grassland
- Protecting at least 20,000 acres of cultivated land to support suitable habitat for native species

The BDCP also plans to propose comprehensive programs for monitoring, research, and adaptive management.

If the process is successful and DFW approves the BDCP as a natural community conservation plan pursuant to Chapter 10 (commencing with Section 2800) of Division 3 of the Fish and Game Code, and determines that the BDCP meets the requirements of this section, and the BDCP has been approved as a habitat conservation plan pursuant to the federal ESA (16 United States Code section 1531 et seq.), the Council shall incorporate the BDCP into the Delta Plan (Water Code section 85320(e)). The Council has a potential appellate role regarding the inclusion of the BDCP in the Delta Plan.

As of this publication, the final public draft of the BDCP and the related environmental impact report/environment impact statement are expected to be released in late 2013. The Council is a Responsible Agency for California Environmental Quality Act purposes.

DP-311

1. **River and floodplain flows.** The Sacramento and San Joaquin rivers and their tributaries provide fresh water into the Delta. Along the margins of the Delta, these rivers seasonally inundate floodplains. Inundated floodplains stimulate the food web by enhancing plant growth, triggering aquatic invertebrate production, exporting food that becomes available to animals downstream, and providing spawning and rearing habitat on the floodplain for fish such as salmon and splittail. In recent decades, floodplains like the Yolo Bypass are flooded primarily by very high flows that flood the Yolo Basin about one year in three. Floodplain restoration could re-establish topographic connections that flood the bypass more often and at lower flows.

2. **In-Delta net channel flows.** Delta flows are primarily driven by tides affected by the moon's cycles, river inflows, in-Delta agricultural diversions, and water exports through the Central Valley Project (CVP) and the State Water Project (SWP). Averaging these influences in any Delta channel over about 1 day gives the "net flow." Locations near the CVP and SWP export pumps, such as parts of Old River and Middle River in the south Delta, experience net "reverse" flows when export pumping by the water projects exceeds these channels' normal downstream flows. The average flow in these channels actually runs backward at times, which affects the Delta's aquatic ecosystems both directly and indirectly (see Figure 4-4). Reverse flow in the southern Delta is associated with increased entrainment of some fish species (Grimaldo et al. 2009) and disruption of migration cues for migratory fish (see the Migratory Corridors for Native Species section for more detail). Reverse and otherwise altered flows caused by upstream reservoir operations, the constraints of artificially connected Delta channels, plus water exports affect Delta habitat largely through effects on water residence time, water temperature, and the transport of sediment, nutrients, organic matter, and salinity (Monsen et al. 2007). These reverse flows could, in turn, affect the behavior of migrating fish, and habitat suitability for resident and migratory fish and other species. Finally, aquatic organisms often get drawn (entrained) into water pumping facilities, as described later in this chapter.

3. **Net Delta outflows.** Net Delta outflow is the sum of all inflows to, and diversions from, the Delta. It is the flow out of the Delta that would occur in the absence of tides (Oltmann 1988). During dry periods, outflow is a low percentage of the instantaneous tidal flow in the western Delta. Nevertheless, over periods longer than 2 weeks, Delta outflow transports river-derived organic matter to Suisun Bay (Jassby and Cloern 2000) and controls the location of the salinity gradient (Jassby et al. 1995). Delta outflow objectives are based on the monthly average location of the low-salinity zone in the western Delta. Outflow variability is recognized as a key factor promoting diverse native fish communities (Moyle and Mount 2007, Moyle et al. 2010).

FLOW IS MORE THAN JUST VOLUME

Flow is not simply the volume of water, but also the direction of flow, the timing of flow, the frequency of specific flow conditions, the duration of various flows, and the rate of change in flows.

Bunn and Arthington (2002) present four key principles underlying the links between hydrology and aquatic biodiversity and the impacts of altered flow regimes: (1) flow determines physical habitat, (2) aquatic species have evolved life history strategies based on natural flow regimes, (3) upstream-downstream and lateral connectivity are essential to organism viability, and (4) invasion and success of nonnative species is facilitated by flow alterations. Altered flow regimes have been shown to be a major source of degradation to aquatic ecosystems worldwide (Petts 2009).

DP-169

Flow Direction in South Delta

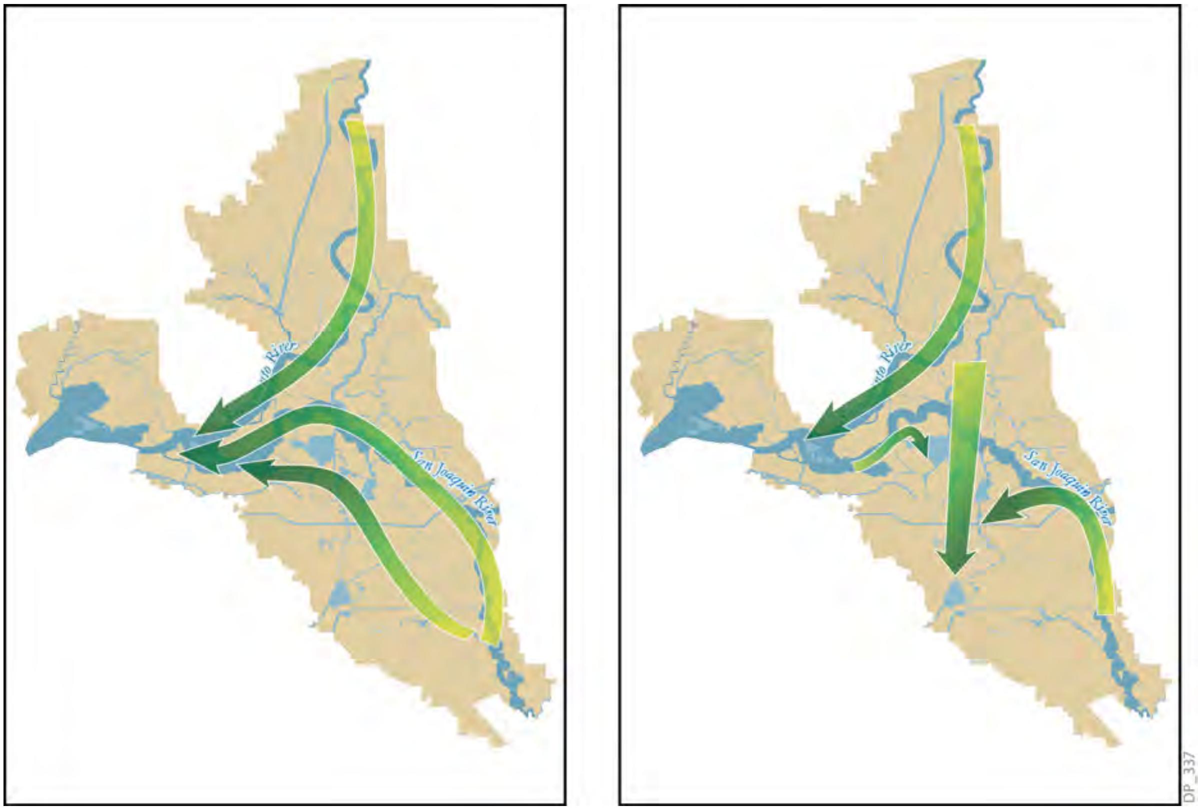
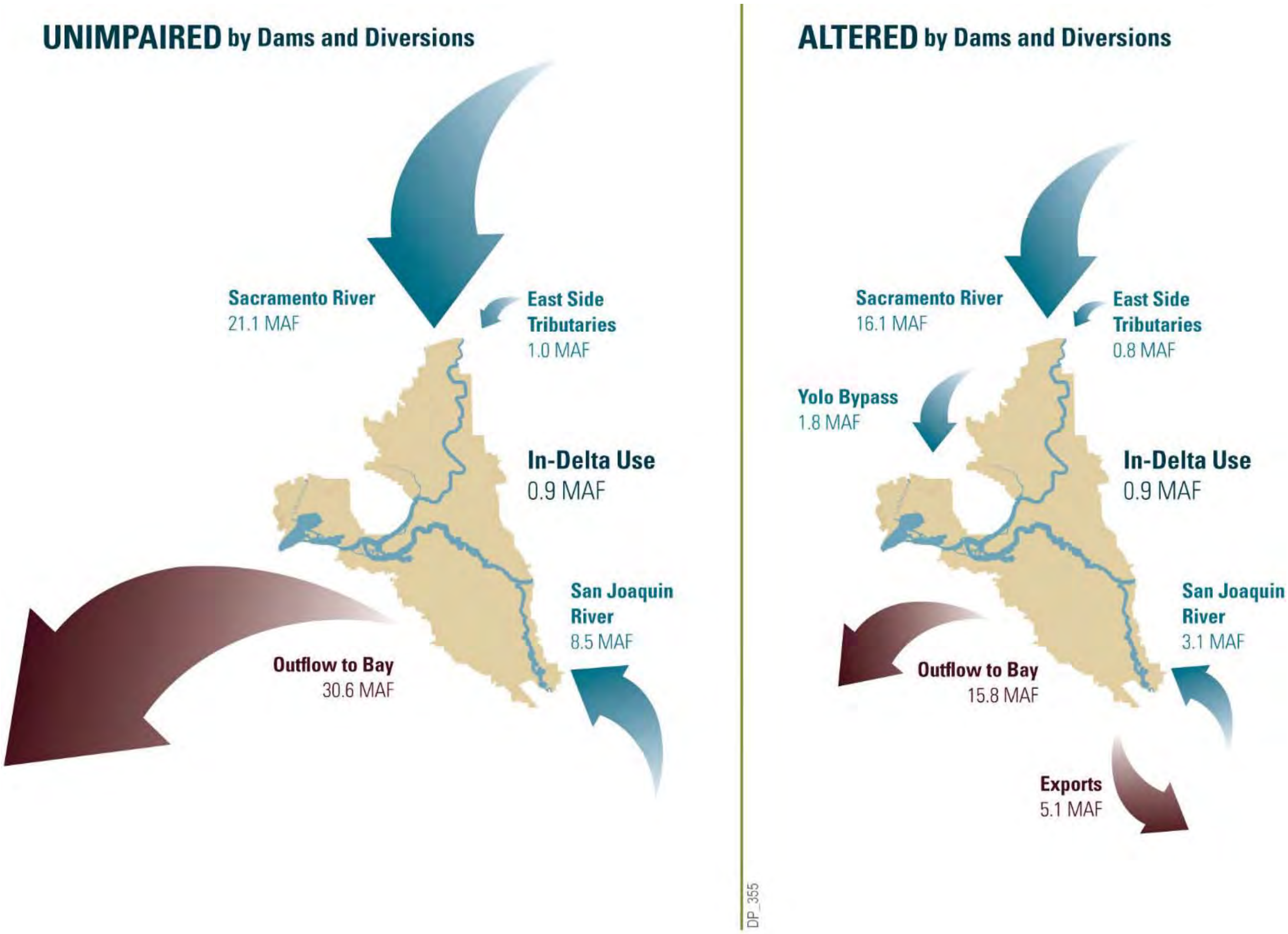


Figure 4-4 The left panel depicts the tidally averaged flow direction in the absence of export pumping. The right panel depicts reversal of tidally averaged flows that occurs during times of high exports (pumping) and low inflows to the Delta.

Present-day Delta flows are very different from historical, natural flows. Water flows have been altered by water supply and flood control infrastructure, including dams on the Sacramento and San Joaquin rivers and their tributaries; levees along these rivers and the Delta's channels; and draining of floodplains, wetlands, and groundwater basins (see Figure 4-5). Flows sometimes have not reflected the Fish and Game Code section 5937 requirement that dam owners should allow sufficient water at all times to pass through a fishway, or in the absence of a fishway, to pass over, around, or through the dam, to keep in good condition any fish that may have been planted or that exist below the dam (DFG 2012). Flows are now closely managed by releases from reservoirs to supply water for agricultural and urban uses, control salinity, and reduce floods. In the Delta, flows have also been rerouted through artificial channels. Flow management and modified Delta channel geometry have altered the salinity and sediment regimes in the Delta (Enright and Culberson 2010, Wright and Schoellhamer 2004), managing salinity for human uses rather than for fish and wildlife. Low winter-spring flows disrupt turbidity and salinity cues for migrating fish (Grimaldo et al. 2009), reduce access to spawning and rearing habits in tributaries and floodplains (Sommer et al. 1997, Feyrer 2004, Feyrer et al. 2007), and limit success for young fish trying to follow natural migration patterns (Feyrer and Healy 2003). Current flow management regulations provide some protection for ecological functions and native species, but the current Delta flow regime is generally harmful to many native aquatic species while encouraging nonnative aquatic species (SWRCB 2010).

Effects of Dams and Diversions on Delta Inflows and Outflows



Data presented as a long-term average. Information based on DWR CALSIM II modeling, which includes projected conditions to protect fisheries.

Delta-Suisun in-Delta use includes water to the Contra Costa Canal and to the Mokelumne and Hetch Hetchy aqueducts.

MAF = millions of acre-feet

Figure 4-5

Water flows more closely approximating the timing, frequency, duration, volume, and rate of change of flow produced naturally by a region's climate are best for native aquatic communities (Poff et al. 1997, Bunn and Arthington 2002, Carlisle et al. 2010). Flow is a major environmental input that shapes ecological processes, habitat, and biotic composition in riverine and estuarine ecosystems such as the Delta. Returning to a more naturally variable hydrograph is a key component of ecosystem restoration because the hydrograph works hand-in-hand with habitat restoration to produce diverse and interconnected food webs, refuge options, spawning habitat, and regional food supplies (Carlisle et al. 2010). Flows should provide species benefits and water supply reliability in the context of current hydrological conditions and degraded habitat. In some cases, flows to benefit the ecosystem will deviate from historical "natural" flows, because the channel geometry, land-water connectivity, and infrastructure limits our ability to mimic historical conditions. Flows will also need to be modified as habitat areas are restored. The Delta Plan, therefore, calls for "more natural functional flows" in the Delta as an important aspect of ecosystem restoration. (See sidebar, More Natural Functional Flow, for a description.)

Flow-related stressors can be reduced or mitigated through improved flow management and concurrent reduction of other stressors. Improved flow management comes from better use of current or improved water infrastructure. The challenge in managing flows is to both restore the Delta ecosystem and improve water supply reliability. Flow-related stressors are likely to increase as population grows and the climate changes. Preparation for these changes must start now.

The State Water Resource Control Board's (SWRCB's) Bay-Delta Water Quality Control Plan (Bay-Delta Plan) identifies water quality objectives to protect beneficial uses of the Bay and Delta, and an implementation program including control of salinity (caused by saltwater intrusion, municipal discharges, and agricultural drainage) through water projects operations. This is a contentious issue of public policy, and the Delta Reform Act directed the SWRCB to develop its new flow criteria using the best available science (Water Code section 85086).

The SWRCB is updating the 2006 Bay-Delta Plan with these steps: (1) review and update water quality objectives, including flow objectives, and the program of implementation in the 2006 Bay-Delta Plan, and (2) make any needed changes to water rights and water quality regulation consistent with the program of implementation. Updating the water quality objectives for the Delta, including an update of flow objectives, is important to protect the Delta ecosystem and the reliability of the Delta's water supplies. The sooner these objectives are set, the earlier the ecosystem can be protected and restored, the greater the possibility that a successful Bay Delta Conservation Plan (BDCP) will be approved, the earlier a more reliable water supply can be improved, and, therefore, the earlier the coequal goals can be achieved. That is why the Delta Plan calls upon the SWRCB to complete its work by specified deadlines. A more detailed explanation of the SWRCB's development of water quality objectives, including flow objectives, is included in Chapter 6.

Entrainment Is One Effect of Altered Flows

Entrainment occurs when fish and other aquatic life are drawn into a water diversion intake and are unable to escape. In the Delta, entrainment occurs primarily at the CVP facilities (Tracy Fish Facility and the nearby Delta-Mendota Canal) and the SWP facilities (including Clifton Court Forebay and the Skinner Fish Facility), as well as other smaller Delta intakes.

Much of the time, net channel flows in most of the south Delta are toward the pumps. This increases the probability that small, weak-swimming young smelt or salmon will be entrained. Depending on the type and size of the fish, the closer a fish is to the pumps, the more likely it is to be entrained. Greater reverse flows caused by pumping in the south Delta increase the numbers of fish entrained.

Some of the entrained fish are "salvaged," meaning they are caught in facilities at the pumps and then trucked and released to an area beyond the pumps' influence. The salvage process decreases the mortality of entrained fish (including salmon). Unfortunately, however, many fish, including delta smelt, are not able to survive the collection, handling, transport, and release.

MORE NATURAL FUNCTIONAL FLOW

What is natural Delta flow? Natural Delta flow is the historical (before 1849) pattern of watershed flows that eventually arrived in the Delta. Historical Delta flows resulted from rainfall in the watershed and the pattern of water storage and release from mountain snowpack, forest and valley soil and vegetation, and the natural topography of creeks, rivers, natural levees, and valley floodplains. These landscape patterns have been modified since 1849, and will largely not be returned to their former state.

Why is natural flow important? Native species are adapted (by natural selection) to the seasonal, interannual, and spatial variability of the historical flow pattern and the functions that come with it. Flows interact with land to create physical habitats and connections where species find food, refuge, and reproduction space. Through a variety of mechanisms, native species can survive, grow, and reproduce better when flows occur in more natural historical patterns.

What does natural flow look like? There were no measurements of natural Delta flow before the watershed was modified by gold mining, agriculture, and water storage. In general, natural flows rise in concert with precipitation patterns and fall slowly as the natural water storage capacity of the watershed is released. Natural flows are not simply water volumes but also include the seasonal timing, magnitude, frequency, duration, and rate-of-change in flows. It is often asserted that "unimpaired Delta inflow" is a good approximation of natural flow. For the Delta, unimpaired flow is the inflow that would be expected if reservoirs were removed but contemporary watershed and valley land uses remained. Unimpaired Delta inflow may overestimate the magnitude of natural Delta inflow and abridge the timing of seasonal peaks.

Will more natural flow work to meet ecosystem goals? Not by itself. Natural flows exist only in the context of natural landscape patterns. The pattern of historical natural flow reflected seasonal and interannual interaction with the historical landscape. For example, historical high flows in winter and spring were intercepted and stored by natural floodplains and then released slowly to the Delta through the summer. Much of the ecosystem functional value of natural flows occurs in these seasonal land and water interactions.

We do not have natural landscapes, so now what? Until large-scale restoration is in place, we can meet ecosystem goals in the interim by using the best available scientific understanding of the *functions* that flows provide to native species. For example, winter-run salmon historically survived low summer flows by finding cold-spring creeks in the watershed for spawning. These creeks are now blocked by dams, but cold water can be released from reservoirs to improve spawning habitat farther down. Another example is using Delta outflow to position the low salinity zone ("X2") in Suisun Bay at key times of the year when the salinity, refuge, and food resources there can benefit native fish. More natural flow is therefore understood to emphasize more natural *functions* rather than the shape of the hydrograph. More natural functional flows could include diverting more flow in wet years and less flow in dry years, as described in Chapter 3. With landscape restoration over time, managing water for functional natural flows should be adaptively managed as ecosystem conditions change. The Delta Plan call for "more natural functional flow" suggests that we can adaptively manage the *functions* that flows provide to the life history needs of native species. Therefore, managing for more natural functional flows protects, restores, and enhances the Delta ecosystem.

DP-347

Alteration of water flows also leads to losses of fish from predation. High rates of predation occur at the pumps, and the sloughs and channels near the pumps. Small fish drawn into this part of the Delta have a very low chance of survival. Juvenile salmon drawn into the central Delta through the Delta Cross Channel or Georgiana Slough also have a lower chance of survival than fish staying in the Sacramento River's mainstem. Whether the effects of flow on fish are direct through entrainment or indirect through increased mortality caused by altered flows and predation, the results are the same: fish lost as a result of Delta diversions.

Because of all these factors, managing flows within the Delta is a difficult but important tool for protecting fish. For example, the SWRCB requires reductions in diversions and increases in San Joaquin River inflows during springtime to increase the survival of outmigrating juvenile salmon. The biological opinions for salmon and smelt include measures to reduce entrainment and indirect loss of fish due to altered flows caused by the SWP and CVP diversions. These actions include restrictions on reverse flows in the Old River and Middle River channels in the south Delta and requirements for closing the Delta Cross Channel gates.

Entrainment does not just occur at the Delta pumps. It also can occur at other diversions upstream from the Delta. Larger diversions upstream and in the Delta are screened, but many smaller diversions are not. In-Delta unscreened diversions do not currently appear to entrain substantial numbers of salmon or smelt.

Habitat

Appropriate habitat is required for any organism to survive and reproduce (Hall et al. 1997). Because no two species have exactly the same requirements, habitats are species-specific components of ecosystems.

Expanding habitats for native species is an essential part of restoring the Delta's ecosystem. Recent biological opinions controlling long-term operations of the CVP and SWP require restoration of at least 8,000 acres of intertidal and associated subtidal habitats in the Delta, including Suisun Marsh (USFWS 2008). They also require restoration of 17,000 to 20,000 acres of floodplain rearing habitat for salmon in the Yolo Bypass and lower Sacramento River, including side channels and re-created floodplain terrace areas (NMFS 2009). Some of the tidal marsh acreage may also fulfill requirements for restored floodplains, depending on its location.

Habitat restoration, like water flow, is not just about quantity (or extent), but also about quality, connectivity, and diversity. Land cover types, such as open-water and riparian vegetation, vary greatly and are only one element of habitat (Lindenmayer et al. 2008); an organism's habitat is much more than just land cover. For example, the area of the Delta covered by open water has not changed substantially during the last few decades, but several open-water fish have declined steeply (Sommer et al. 2007, Baxter et al. 2010). This suggests that some of the Delta's open waters have become inhospitable to these certain fish species. The functional habitat available to these open-water fish has shrunk even though the area covered by open water has remained fairly stable. This means that simply changing land cover (for example, increasing riparian habitat) does not automatically increase target species. Other stressors such as poor water quality, predation, or entrainment may make these areas unsuitable.

Habitat loss and fragmentation resulting from human land use causes species loss worldwide (Foley et al. 2005). In estuaries and coastal areas, habitat destruction, coupled with exploitation such as overfishing, are the leading causes of species declines and extinctions (Lotze et al. 2006). Habitat restoration can help recover native species, particularly when other stressors such as altered flows, degraded water quality, or predation by introduced species are also reduced (Carlisle et al. 2010, Lotze et al. 2006).

Taking a large view of an ecosystem, habitats are species-specific "patches" in spatially varied landscapes. The survival and success of organisms is closely associated with the total amount of usable habitat, as well as with habitat patch sizes, shapes, and arrangements (Hannon and Schmiegelow 2002). Habitats that are too small, fragmented, or isolated may not provide long-term support for specific organisms. In general, more, larger, and better-connected patches of a specific habitat create the conditions for persistence or recovery of the species associated with that habitat (Lindenmayer et al. 2008). (See sidebar, Landscape Ecology: A Fundamental Tool for Restoration Planning.)

Much of the original habitat for the Delta's native fish, wildlife, and plants has been urbanized or converted to agriculture over the past 160 years (Healey et al. 2008, Moyle et al. 2010, Baxter et al. 2010). This habitat loss is one of the largest legacy stressors to the Delta ecosystem. The current Delta ecosystem continues to be productive, but its habitat types and conditions support a much different mix of species than the historical Delta. Many of the thriving species are nonnative, such as largemouth bass and the Brazilian water weed *Egeria densa*. Some consider a few nonnative species, such as bass prized by anglers, to be desirable. But too many nonnative plants and animals can upset an ecosystem's balance, creating conditions unsuitable for native aquatic and terrestrial species (Sommer et al. 2007, Healey et al. 2008, Baxter et al. 2010). This conflict and the inadequate habitat for native species that reside in and migrate through the Delta is an important current ecosystem stressor that must be addressed.

LANDSCAPE ECOLOGY: A FUNDAMENTAL TOOL FOR RESTORATION PLANNING

Landscape ecology examines the influence of spatial patterns on ecological processes (Wiens 2002) and considers the ways that species use the landscape for finding food and refuge, and for adapting to change (Simenstad et al. 2000, Lindenmayer et al. 2008). The mosaic of landscape features—or "patches"—and the connections between patches affect species' locations, food and cover, the energy required to obtain those resources, and, ultimately, survival. The landscape perspective considers connections and exchanges between uplands; riversides and wetland edges; and the sloughs, channels, and bays that make up estuarine aquatic habitats. The food webs of these adjacent systems exchange organisms and energy that, in turn, can increase the productivity of each (Cloern 2007). Native estuarine species—terrestrial, semiaquatic, and aquatic—are adapted to the rhythms of the landscape's mosaic of connected habitats and its dynamic processes.

From a landscape perspective, "form begets function." Therefore, correct spatial structure and patterns are prerequisites for restoring and maintaining desired ecosystem processes and functions, and for providing appropriate habitat for native species. In the long term, restoring spatial patterns at ecologically appropriate scales can promote the "self-repair" of ecosystem processes and functions (Teal et al. 2009) and increase resilience to stressors. Consequently, this approach could reduce the operating and maintenance costs of restoration in an era of limited resources. Planning for ecosystem restoration should always consider appropriately large spatial scales (regional or larger), but restoration actions can proceed at smaller scales to optimize the benefits that can be achieved with the often limited opportunities and resources available for restoration (Hermoso et al. 2012).

Additionally, landscape ecology considers people's role in shaping landscape patterns and processes (Turner 1989). Restored landscapes often have agricultural and urban neighbors. Each land use affects the other because they are connected by air, land, and water. Yet humans often want conflicting things (nature areas nearby with abundant wildlife, but also with convenient recreation facilities, no mosquitoes, and no impacts on adjoining farms). A functioning ecosystem depends on many things, including understanding and dealing with its relationship to human activities. The current regulatory and political framework for restoration projects often puts short-term benefits, such as low acquisition cost or immediacy of land availability, before long-term benefits of connectivity and appropriateness of scale. Landscape ecology provides a set of tools for assessing and prioritizing limited restoration opportunities. For example, using the principles of landscape ecology, decisions about land acquisitions for restoration must address how small parcels that become available for restoration might be connected and combined to maximize ecological benefits over the long term.

DP-313

The Importance of Land Elevation in Habitat Restoration

Opportunities for habitat restoration in the Delta are constrained first and foremost by the elevation of land, which determines the potential of an area to be restored. As described in Chapter 5, much of the Delta has subsided too deeply to restore its original ecological functions (see Figure 4-6).

Deeply subsided Delta lands can provide terrestrial and wetland habitat for native species only at great cost and with intensive management. They offer few opportunities to recover native ecosystem forms and functions. However, deeply subsided islands could include seasonal wetlands for waterfowl and wildlife-friendly agriculture. Actions that promote carbon sequestration, subsidence reversal, and improved migratory bird habitat are especially valuable.

The most promising restoration opportunities are found in the less-subsided flood basins, river corridors, and brackish tidal marshes on the Delta's perimeter, leading the Council to recommended six priority habitat restoration areas:

- **Yolo Bypass, from the Fremont Weir south toward the Delta.** Winter and spring flooding of the Yolo Bypass provides substantial benefits for spawning and rearing of Sacramento splittail and rearing of salmon (Sommer et al. 2001, Moyle et al. 2007). Projects in the planning stage include fish passage improvements and various approaches, such as notching the Fremont Weir to increase the frequency and duration of inundation during times of the year critical for spawning and rearing of native fish. Restoration of the Yolo Bypass can create conditions that promote enhanced growth and survival of juvenile spring- and winter-run salmon, among other species, and can benefit other migrating salmon.

Habitat Types Based on Elevation, Shown with Developed Areas in the Delta and Suisun Marsh

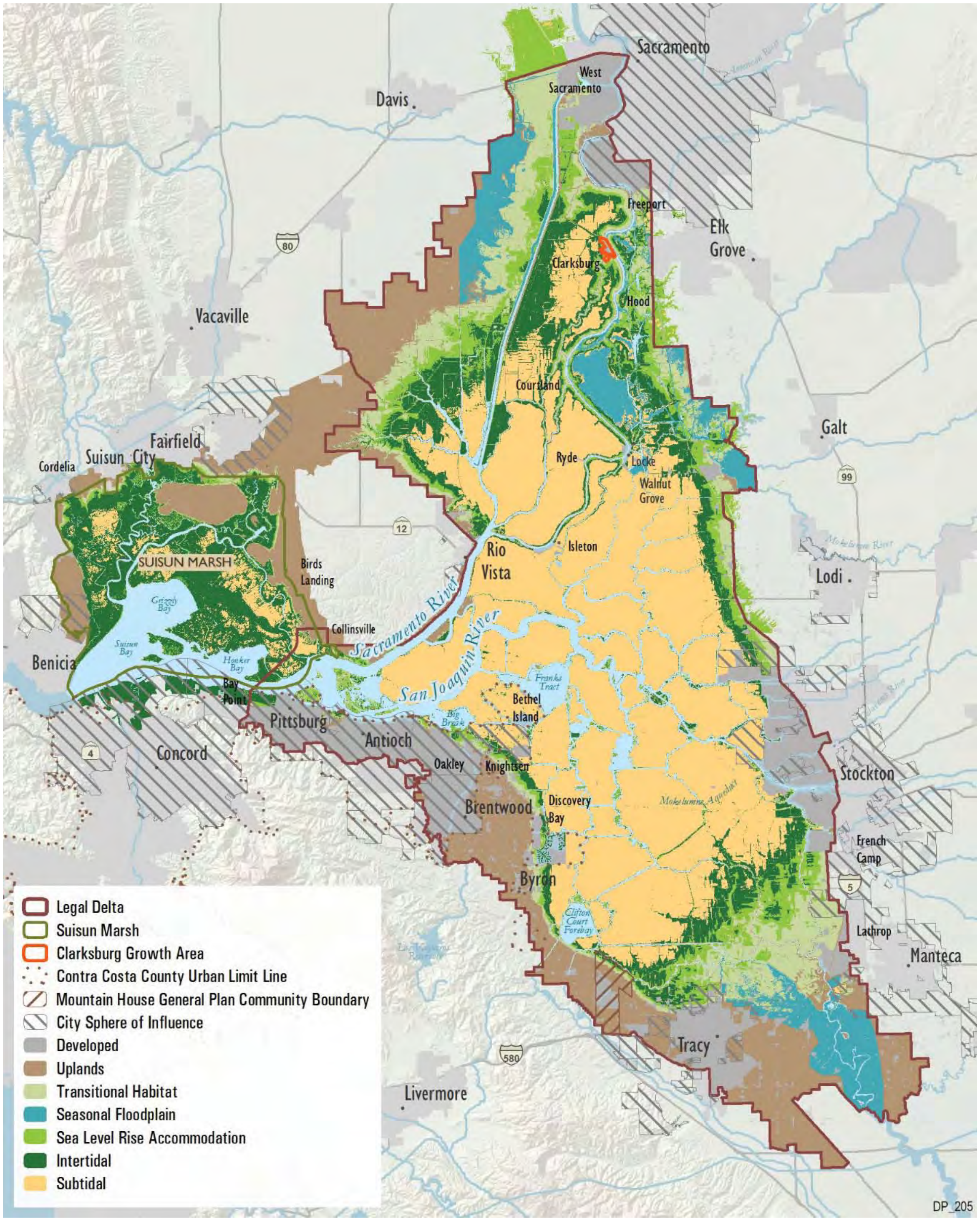


Figure 4-6 *Source: Adapted from DFG 2011*

- **Cache Slough Complex, southwest of the Yolo Bypass.** The flood basins entering the Cache Slough Complex are at the interface between river and tidally influenced portions of the Delta. A restoration project in this area is Liberty Island, which is being allowed to passively restore to marsh after floods breached the island's levees in 1997. Projects in the planning stage include California Department of Water Resource's (DWR's) Prospect Island restoration project. Habitat restoration at Cache Slough can create conditions that help recover delta smelt and that benefit migrating salmon. See the sidebar, Applying Adaptive Management to Ecosystem Restoration, for a hypothetical example implementing principles of adaptive management in projects such as these.
- **Cosumnes River–Mokelumne River confluence.** An existing restoration project is the Cosumnes River Preserve floodplain. Projects in the planning stage include DWR's North Delta Flood Control and Ecosystem Restoration Project on McCormack-Williamson Tract. Restoration here can benefit migrating salmon and contribute to the Delta's food webs.
- **Lower San Joaquin River floodplain between Stockton and Manteca.** Historically, the south Delta and its connection to the lower San Joaquin River contained a complex network of channels with low natural berms, large woody debris, willows, and other shrubs with upland areas supporting open oak woodlands. Projects in the planning stage include the Lower San Joaquin Flood Bypass proposed by the South Delta Levee Protection and Channel Maintenance Authority and its partners. Restoration to a mix of tidal marsh, riparian habitats, and wildlife-friendly agriculture could create conditions to recover riparian brush rabbits and Swainson's hawks, benefit migrating salmon, and serve to reduce the risks from flooding for urban areas.
- **Suisun Marsh.** This is the largest wetland area on the West Coast of the contiguous United States. Suisun Marsh is mostly managed for waterfowl, with levees that disconnect its wetlands from the estuary. An ongoing restoration project is DWR's Blacklock Restoration Project. Projects in the planning stage include California Department of Fish and Wildlife's (DFW's) Hill Slough Restoration Project. Restoration of tidal marsh and associated habitats here can create conditions that contribute to food webs in Suisun and Honker bays, and aid the recovery of longfin smelt and spring- and winter-run salmon.

  Unique local benefited species would also include Suisun song sparrows, saltmarsh harvest mice, and plants such as soft bird's-beak and Suisun thistle. Enhanced management of wetlands can reduce impacts on water quality while still maintaining or improving habitat for waterfowl of other wildlife.
- **Western Delta/Eastern Contra Costa County.** Some islands and tracts at appropriate elevations may be desirable sites for restoration of tidal marsh and channel margins to support food webs and provide habitat for native species. Decker Island is a recent restoration project in this area, and restoration at Dutch Slough is planned. Additional restoration of other islands or tracts may be considered in the BDCP or in local Natural Community Conservation Plans/Habitat Conservation Plans.

These six regions have been highly altered by more than a century of human use and exposure to multiple stressors. Returning a portion of these altered regions to habitat for native species requires a careful assessment of opportunities and challenges. Recommendations provided later in this chapter include actions to prevent or mitigate adverse impacts on opportunities for habitat restoration in these priority restoration areas.

<table>
<tr><th colspan="3">Applying Adaptive Management To Ecosystem Restoration</th><th>An adaptive management approach to ecosystem restoration should be used to plan for and assess the ecological outcomes of the restoration action. The following is a hypothetical example of how the Council’s three-phase and nine-step adaptive management frame-work (see Appendix C) could be applied to an ecosystem restoration project in the Cache Slough Complex.</th></tr>
<tr><th colspan="3">Adaptive Management Step</th><th>Hypothetical Cache Slough Ecosystem Restoration Project</th></tr>
<tr><td rowspan="4">Plan</td><td>1</td><td>Define/redefine the problem</td><td>The Cache Slough Complex includes high biodiversity; however, ecological processes and habitat that benefit native species in the Cache Slough Complex are degraded.</td></tr>
<tr><td>2</td><td>Establish goals, objectives, and performance measures</td><td>Goal: Re-establish natural ecological processes and habitats to benefit native species in the Cache Slough Complex.
Objective: Re-establish the hydrologic, geomorphic, and ecological processes necessary for the long-term sustainability of native habitats, and the plant and animal communities that depend upon them. Improve floodplain connectivity and aquatic habitat quality for native estuarine species, including delta smelt, longfin smelt, Sacramento splittail, and Chinook salmon, by offering a suite of natural habitats and improving the food web fish require.</td></tr>
<tr><td>3</td><td>Model linkages between objectives and proposed action(s)</td><td>The Cache Slough Complex provides high potential for restoration success because of its physical and biological attributes (such as tidal range, elevation, high amounts of suspended sediment, abundant zooplankton, and observed use by delta smelt). It is hypothesized that improved vernal pool and grassland habitats along with broad nontidal, freshwater, emergent-plant-dominated wetlands that grade into tidal freshwater wetland, shallow subtidal, and deep open-water habitat will increase the amount and quality of food for native species in the estuary. It is hypothesized that restoring tidal channel, wetland, and upland networks will improve conditions for native fishes. It is hypothesized that increases in the quality and quantity of food for native species will lead to increases in native species populations in the estuary. Native species expected to benefit from this restoration include delta smelt, juvenile Chinook salmon, Sacramento splittail, and longfin smelt.</td></tr>
<tr><td>4</td><td>Select action(s) (research, pilot, or full-scale) and develop performance measures</td><td>Pilot-scale restoration project in the Cache Slough Complex: restore a subset of the processes supporting the creation of tidal channel, wetland, and upland networks to support native fishes.
Performance measures:
▪ Administrative – Properties are identified for the pilot study. Funding sources and budgets for the project and monitoring are in place. Properties are acquired. Restoration planning and design is completed. Environmental compliance permits are obtained. Restoration contractors are selected.
▪ Output – Pilot-scale Delta habitat restoration project is implemented. Progress toward restoring diverse and interconnected habitats for native resident and migratory species in the Cache Slough Complex.
▪ Outcome – Progress toward achieving viable populations of native resident and migratory species. Trends in native Delta species are upward over the next decade.</td></tr>
<tr><td rowspan="2">Do</td><td>5</td><td>Design and implement action(s)</td><td>Design and implement the pilot-study restoration project.</td></tr>
<tr><td>6</td><td>Design and implement monitoring plan</td><td>Design and implement the monitoring plan, including baseline monitoring of food abundance for pelagic organisms. Monitor the extent and quality of targeted habitats, connectivity of habitats, and abundance and diversity of species.</td></tr>
<tr><td rowspan="3">Evaluate and Respond</td><td>7</td><td>Analyze, synthesize, and evaluate</td><td>Analyze, synthesize, and evaluate the status and trends of changes in habitats, connectivity of habitats, abundance, and species health and diversity.</td></tr>
<tr><td>8</td><td>Communicate current understanding</td><td>Provide project manager(s) and decision makers with annual reports of synthesized information learned. For example, provide a score card of the status and trends of species abundance and diversity, habitat connectivity, and so on.</td></tr>
<tr><td>9</td><td>Adapt</td><td>The managers and implementers of the restoration project reconsider their understanding of the problem statement and conceptual model, and decide whether or not to expand from a pilot-study project to a larger-scale restoration effort.</td></tr>
</table>

DP-332

Migratory Corridors for Native Species

Habitat restoration often targets resident species that use the restored habitat year-round. Successful restoration, however, must also consider species that only periodically use particular habitat patches and corridors. The historical Delta provided migration corridors and rearing habitat for many migratory bird and fish species, including the threatened greater sandhill crane, many species of ducks and geese, salmon, sturgeon, and the introduced striped bass.

In the past, the Delta was a migration route and also an important nursery area for young salmon (or "smolts"). Much of the Delta today presents real risks to migrating salmon; it is no longer a suitable nursery for salmon smolts (Williams 2006). Some Delta channels do provide a greater chance of fish survival than others. For example, salmon leaving the Sacramento River and entering the interior Delta through the Delta Cross Channel have significantly lower survival than fish that stay in the river (Newman 2008), demonstrating that the central Delta has become a gauntlet of risk instead of a viable migratory corridor.

Entrainment at the CVP and SWP southern Delta pumps and increased predation kill salmon smolts. Toxic contaminants and periods of low dissolved oxygen can be harmful. Important factors for route selection and survival of salmon smolts on their way to the ocean include differences in flows through different channels, feeding opportunities, growth rates, and vulnerability to predation (Perry et al. 2009).

On their way back from the ocean to spawn, adult salmon must navigate a maze of Delta waterways where water from many different sources is mixed in artificially connected channels, and where rivers sometimes flow backward (reverse net flows in Old and Middle rivers; see the Delta Flows section) (Monsen et al. 2007). A unique problem is presented by the San Joaquin River, whose polluted and reduced flows are often drawn to the SWP and CVP pumps as a result of reverse flows. During these times, almost no water from the San Joaquin River reaches the confluence with the Sacramento River. Instead, water from the Sacramento River and its tributaries fills most of the Delta, obscuring and confusing the chemical and flow cues that salmon and other migratory fish depend on to find their destinations.

In addition to altered water flow and chemical disruption, migratory fish encounter dams, reservoirs, and other physical barriers that hinder their historical migration. The most formidable barriers are upstream on the Sacramento and San Joaquin rivers and their tributaries, especially the many large and small dams associated with reservoirs, including Shasta, Folsom, and Millerton lakes and Lake Oroville. In the Central Valley, less than one-fifth of the historical spawning habitat is still accessible to Chinook salmon and steelhead (Reynolds et al. 1993, Yoshiyama et al. 1996).

Physical barriers in the Delta help maintain water supplies for agriculture but interrupt fish migration; structures with ledges and drops, such as bridge pilings, boat docks, narrow channels with riprapped edges, or the intakes of the SWP and CVP pumps, create attractive spots for predatory fish to feed on migrating species. The Delta Cross Channel is an example. Sometimes, a barrier can have positive effects. Federal, State, and local officials have recently tested novel bio-acoustic fish fences (BAFFs) at Old River and Georgiana Slough that use light, sound, and air bubbles to steer migrating fish into channels that are thought to provide better habitat and a greater chance of survival.

Some high-quality migratory fish rearing and migration habitat remains at the margins of the Delta, if not in its core. The Yolo Bypass and Cosumnes River floodplains provide good migratory and rearing habitat for salmon, and important habitat for other native fish, birds, and bats. DFW manages the Vic Fazio Yolo Wildlife Area, a 16,000-acre public-private restoration project in the Yolo Bypass, to promote waterfowl and other bird populations. The 46,000-acre Cosumnes River Preserve is jointly owned and operated by The Nature Conservancy, Ducks Unlimited, the Bureau of Land

Management, DFW, DWR, Sacramento County, and private owners to create, enhance, and protect a variety of habitats. These are good illustrations of ecosystem and flood risk reduction projects working together. Wildlife-friendly agriculture also occurs in these floodplain preserve areas and their surroundings. During winter and early spring floods, these floodplains provide plentiful food for migrating salmon and native fish such as splittail, prickly sculpin, and Sacramento sucker (Sommer et al. 2001, Crain et al. 2004). Salmon migrating through these floodplains grow faster and have greater survival. (See sidebar, Better Habitat Equals Greater Growth.) Native fish do particularly well when flows through these floodplains follow more natural patterns. Early February through April, strong flood flows with cool water temperatures benefit many young native fish. Nonnative fish benefit more from later and lower flows with higher temperatures. Floodplain restoration should thus focus on early flooding followed by careful draining. This provides important migration and nursery habitat for native species while keeping nonnative species, including predators, at bay.

BETTER HABITAT EQUALS GREATER GROWTH

This comparison illustrates faster growth in floodplain habitat compared to river habitat. Salmon on the left were reared within Cosumnes River channel habitat, and the salmon on the right were reared within Cosumnes River floodplain habitat. All salmon shown are the same age.

Source: Jeffres et al. 2008

DP-162

Actions above and below the Delta also complement actions in the Delta to restore migratory corridors for fish and wildlife. The Bureau of Reclamation, U.S. Fish and Wildlife Service, and DFW have modified Shasta Dam to release colder water for salmon and trout, removed barriers to fish migration such as the Red Bluff Diversion Dam, screened water diversions to reduce entrainment, restored riparian habitats at the Sacramento River National Wildlife Refuge (NWR) and San Joaquin River NWR, and improved habitats in Sacramento and San Joaquin river tributaries where salmon spawn. Efforts to restore flows in the San Joaquin River also can rebuild these migratory corridors.

For example, on Battle Creek, actions to remove multiple dams and fish ladders are being implemented through the Battle Creek Salmon and Steelhead Restoration Project. The primary objective of the restoration project is to restore the ecological processes that would allow the recovery of steelhead and Chinook salmon populations in Battle Creek while minimizing the loss of clean and renewable hydroelectric power through modifications to the hydroelectric project. This project is among the largest coldwater anadromous fish restoration efforts in North America and will restore approximately 42 miles of habitat in Battle Creek and an additional 6 miles of habitat in its tributaries. It will also help restore critically imperiled winter- and spring-run Chinook salmon and Central Valley steelhead. Additional restoration actions are planned for other Sacramento River tributaries including Clear Creek, Deer Creek, and Mill Creek.

On the mainstem of the San Joaquin River between Friant Dam and its confluence with the Merced River, the San Joaquin Settlement Agreement will increase flows, expand channel capacity, and remove barriers to migration to restore spring-run Chinook salmon runs. This long-term action is expected to occur in stages over 20 years. On the Tuolumne River, the largest tributary of the San Joaquin River, the Central Valley Project Improvement Act (CVPIA)

Restoration Plan actions focus on restoring spawning, rearing, and floodplain habitat. The Bobcat Flat Restoration Project includes excavation of 48,500 cubic yards of gravel and coarse material that will be used to restore 1.6 miles of fall-run Chinook salmon and Central Valley steelhead spawning and rearing habitat. Similar habitat restoration projects have been implemented or are planned on other tributaries of the San Joaquin River and the Delta, including the Merced, Stanislaus, Calaveras, and Mokelumne rivers. However, 16 years after the creation of the CVPIA restoration fund, a panel of independent scientists issued a report on the CVPIA Fisheries Program (Reclamation and USFWS 2008) concluding that more could be done to effectively address the most serious impediments to survival and recovery of salmonids.

Wetlands bordering San Pablo Bay downstream of the Delta are home to a host of native and nonnative fish, waterfowl, shorebirds, other wildlife, and endangered plants and important stopping points on the Pacific Flyway. Uncommon species found in and around San Pablo Bay wetlands include longfin smelt, delta smelt, salt marsh harvest mouse, California clapper rail, San Pablo song sparrow, and black rail. All Central Valley anadromous fish migrate through the bay and depend on its open water and marshes for some critical part of their life cycle. The bay and its adjacent marshes are also important nursery grounds for many marine, estuarine, and anadromous fish. More than 40,000 acres of diked baylands and wetlands bordering the San Pablo Bay have been protected and are being restored.

In the Sacramento and San Joaquin valleys, actions to protect, restore, and enhance wetlands carried out by the Central Valley Joint Venture have significantly increased wildlife habitat resources for migratory waterfowl, shorebirds, waterbirds, and riparian songbirds in accordance with conservation actions identified in the Joint Venture's Implementation Plan. The Joint Venture establishes population objectives for these migratory birds then determines the appropriate amount of food, habitat, and water supply necessary to meet the objectives. Wetland restoration becomes a priority when habitat and forage needs for population objectives are not being met.

Successful recovery of native species requires effective habitat restoration. In addition to restoring physical habitat and corridors for movement, reducing other stressors is important too. Together, they help in achieving the coequal goal of a healthier Delta ecosystem.

Riparian and Shaded Riverine Aquatic Habitat

Fish and birds migrating through the Delta need abundant floodplains and appropriate water flows; but they also need streamside trees and shrubs that shade and cool the rivers; undercut riverbanks where smolts and other small fish rest and hide; and trees that drop insects and leaves that contribute to the food web and provide cover, food, and nest sites for songbirds and other wildlife. Unfortunately, along most of the Sacramento and San Joaquin rivers, levees are near the water's edge, not set back from rivers, leaving little room for these habitat features, which often are provided only by trees growing immediately adjacent to or even on the levees themselves.

Because of the importance of these streamsides, water supply or flood risk policies and projects that affect the Delta's rivers and other channels should consider the impact on remaining riparian and shaded riverine habitat. Setting back levees can create additional area for habitat and increased capacity for flood flows. Setting back levees, however, can be expensive and difficult. At the same time, there is considerable controversy over the current policy of the U.S. Army Corps of Engineers (USACE) to require removal of trees and most shrubs from levees under their jurisdiction. A technical manual issued by the Federal Emergency Management Agency (FEMA) for earthen dams has been relied upon heavily to support this vegetation removal policy (FEMA 2005). There is little riverine habitat left. If implemented as proposed, the USACE's order would destroy much of what remains. The Delta Plan calls for the

USACE to reconsider and change its policy in order to protect riverine habitat.

Safe Harbor Agreements

Voluntary safe harbor agreements between wildlife agencies and landowners can contribute to the recovery of species protected by the State or federal Endangered Species Acts. These agreements assure the landowners that the presence of endangered species on their property will not result in restrictions on other activities undertaken on their land. Facilitating and creating standard rules for these agreements with Delta landowners may encourage more landowners to participate in conservation programs.

Suisun Marsh and the Bay Conservation and Development Commission

The Suisun Marsh is one of the Delta Plan's priority habitat restoration areas. It is one of the largest contiguous estuarine wetlands in North America; an important nursery for fish; a wintering and nesting area for waterfowl and waterbirds; and an essential habitat for plants, fish, and wildlife, including several scarce and sensitive species. Suisun Marsh offers unique restoration opportunities because of its position in the Delta ecosystem and the diversity of physical processes it hosts. Suisun Marsh harbors a greater percentage of native fish than the remainder of the Delta, in part because its brackish water limits nonnative species. Additionally, the marsh has many diverse tidal sloughs that provide options for food and refuge (Moyle et al., 2010).

Unlike the deeply subsided Delta, much of the Suisun Marsh is still at elevations suitable for restoration of intertidal habitat, including tidal marsh and shallow water habitat. This area provides the brackish portion of the estuary with the potential to support productive and complex food webs, and with space to adapt to sea level rise. State and local land use policies should reflect the unique role that Suisun Marsh can play.

The San Francisco Bay Conservation and Development Commission (BCDC) is responsible for protecting San Francisco Bay and its shoreline, including Suisun Marsh, through the San Francisco Bay Plan, as described in Chapter 5. It is developing regional strategies to address the impacts of sea level rise and climate change on the Bay. BCDC provides special protection of the Suisun Marsh under the Suisun Marsh Preservation Act through the Suisun Marsh Protection Plan (SMPP). BCDC recently amended the San Francisco Bay Plan to address climate change and sea level rise. The climate change policy, among other things, incorporates sea level rise projection ranges consistent with those developed by the California Ocean Protection Council (2011) and calls for development of a long-term regional strategy to address sea level rise and storm activity. The SMPP and the Suisun Marsh Local Protection Program should also be amended to address climate change and rising sea level.

Ecosystem Water Quality

Chapter 6 deals with water quality issues and contains many recommendations for action. Impaired water quality makes it much harder to restore a healthy Delta ecosystem. Recommendations in Chapter 6 regarding salinity and environmental water quality cover key linkages between ecosystem restoration and water quality.

Consistently good water quality is crucial for successful restoration of aquatic habitats, sustenance of native plants and animals, and other beneficial uses of Delta water. Salinity should be more consistent, with a naturally variable estuarine hydrograph with high-quality river inflows. Nutrient composition and concentrations should not cause excessive growth of nuisance aquatic plants or blooms of harmful algae, and should support diverse and productive aquatic food webs. Dissolved oxygen levels, water temperatures, turbidity, and other attributes should meet the needs of native species. At all times the Delta should be free of substances that exceed toxic concentrations. Discharge of treated wastewater, urban runoff, or agricultural return flows should not adversely affect the Delta.

Chapter 6 focuses on four key areas where the best available science shows the need to protect and improve water quality to achieve the coequal goals (see Chapter 6 for a complete discussion):

- Requiring Delta-specific water quality protection
- Protecting beneficial uses by managing salinity
- Improving drinking water quality
- Improving environmental water quality

Nonnative Species

Among the world's estuaries, the Delta and San Francisco Bay are among the most invaded by nonnative species (Cohen and Carlton 1998). Some nonnative species have been in the Delta for more than a century and seem to be a permanent feature of the Delta ecosystem. Because it is nearly impossible to eradicate nonnative species once they are established, many can be considered legacy stressors that can be managed but not eliminated.

However, the introduction of any new nonnative species has consequences, particularly for native species. Nonnatives can take over habitat space, compete for food and nutrients, alter food webs, modify the physical habitat structure, or prey upon native species (DFG 2011). In wetlands and riparian areas, nonnative vegetation often crowds out native plants and reduces diversity used by resident and migrating birds and other animals (PRBO CalPIF 2008). The result is that nonnative plants, invertebrates, and fish may replace native species, and that change on their native counterparts is often combined with the other stressors such as altered flow, impaired habitat, and poor water quality.

Significant nonnative species in the Delta include (DFG 2008):

- **Overbite clam.** The overbite clam, a bottom-dwelling filter feeder, entered the Delta in the late 1980s and adapted well to its brackish areas. Overbite clams contribute to the reduction of algae and some invertebrates in the Delta, especially in Suisun Bay (Kimmerer 2006), causing loss at the base of the food web, which contributes to the decline of delta smelt and other open-water fish (Sommer et al. 2007).
- **Asian clam.** The Asian clam was first found in the Delta in 1946 (USGS 2001). This clam does not tolerate saline water, but is abundant in freshwater parts of the Delta and in the mainstems of the Sacramento and San Joaquin rivers. Ecologically, this species can alter channel bottoms and competes with native freshwater mussels for food and space (Claudi and Leach 2000). Overbite and Asian clams cannot be effectively controlled, according to many experts (Healey et al. 2008), but they may be managed by manipulating environmental conditions such as flow or salinity to seasonally control their distribution.
- **Zooplankton.** Surveys of Delta waters reveal that introduced zooplankton, probably discharged in ocean ship ballast water in the San Francisco Bay and Delta, have almost completely replaced the original native zooplankton (Winder and Jassby 2011). The success of nonnative zooplankton species was accompanied by an overall decline in zooplankton biomass and size that suggests a decrease in their nutritional value for fish (Winder and Jassby 2011).
- **Nonnative invasive aquatic plants.** The floating water hyacinth, imported as a landscaping plant, proliferated in the Delta in the early 1980s. The Brazilian waterweed was introduced in the 1960s, probably from home aquariums, but did not reach nuisance levels until after the 1987-1992 drought (Jassby and Cloern 2000). These and other nonnative aquatic weeds in the Delta, including water pennywort, Eurasian water milfoil, and parrot feather, pose serious problems to native plants and animals, and hinder boating. The weeds flourish in a wide area where they act as powerful "ecosystem engineers" (Jones et al. 1994, Breitburg et al. 2010) through alteration of habitats, sometimes creating dense mats or thickets that displace native plants, reduce the food web

productivity, reduce turbidity, and interfere with water conveyance and flood control facilities. These invasive plants benefit nonnative predatory fish like largemouth bass. Areas of dense, submerged aquatic vegetation (SAV) may reduce the abundance of native fish larvae and adults (Grimaldo et al. 2004, Nobriga et al. 2005, Brown and Michniuk 2007). Restoration of aquatic habitats must be designed and managed to reduce nonnative SAV if conservation goals are to be met (Nobriga and Feyrer 2007).

- **Bass and sunfish.** Several species of nonnative fish have been introduced in the Delta. Largemouth and smallmouth bass, sunfish including bluegills and warmouth, crappies, and other fish in the centrarchid family are the best examples. They prey on salmon smolts, smelt, and other native fish. The increase in SAV, especially in and around "flooded islands" in the central Delta, enhances bass and bluegill populations (Brown and Michniuk 2007) and possibly populations of other nonnative predators (Grimaldo et al. 2009). Centrarchids harm native fish through predation and competition (Nobriga and Feyrer 2007, Brown and Michniuk 2007). The distribution of centrarchids may be modified by managing conditions such as water velocity, nutrients, salinity, and turbidity to reduce SAV.

The invasion of nonnative species is in the category of globally determined stressors because these species' arrival in the Delta is the result of large-scale natural processes and human activities that are beyond the purview of the Delta Plan. Nonnative species have persisted because they found favorable environments in which to live. Native species are adapted to the varied, complex floodplains, marshes, and other habitats of the historical Delta, with its tidal currents and river flows that constantly change physical, chemical, and biological conditions. In contrast, the stabilized flow pattern, altered habitats, and impaired water quality of the modern Delta often favor nonnative species. Reducing the impacts of nonnative species in the Delta will require addressing flow alterations, pollution (especially nutrients), and physical habitat characteristics.

Future invasions by zebra and quagga mussels are likely and will require considerable preparation, followed by interagency coordination and action. These mussels are an example of an "anticipated stressor" under the Delta ISB's classification of stressor types. Neither has been observed in the Delta yet, but they have proven to be highly invasive when conditions are right. They pose threats comparable to threats from the overbite and Asian clams. They can colonize hard and soft surfaces, often in large densities (greater than 2,800 individuals per square foot) that impede the flow of water through canals and pipes. These mussels also remove particulates in the water, unnaturally enhancing water clarity.

Once introduced, nonnative species are difficult and expensive to control, and often impossible to eradicate. The California Department of Boating and Waterways supports programs to control Brazilian waterweed and water hyacinths where they hinder boating, but only where conditions create the worst nuisances. The best way to prevent new infestations is to avoid the introduction of new species. Improvements in managing ballast water by shipping companies have been instituted recently, but likely more needs to be done.

There is no agreement about the value—or lack of value—of nonnative species. Opinions vary depending on the species and the interest of Delta users. Striped bass are nonnative but prized for their sport and economic value. Introduced to the Delta in the nineteenth century, they prey on native open-water fish such as delta smelt, longfin smelt, and juvenile salmon and steelhead. Striped bass are at the center of an ongoing debate about whether fishing regulations for introduced species should conserve the fish or should be less restrictive to reduce their abundance (DFG 2011).

The draft Ecosystem Restoration Program (ERP) Conservation Strategy acknowledges that many nonnative species will likely remain in the Delta, and emphasizes prevention and adaptation strategies such as public education, preventing establishment of additional nonnative species, and reducing the impacts of established nonnative species. DFW issued its *California Aquatic Invasive Species Management Plan* in 2008, which aims to coordinate the various State efforts to minimize harmful ecological, economic, and human health impacts from aquatic invasive species (DFG 2008).

Hatcheries and Harvest Management

In the Delta, people have harvested fish and shellfish for millennia. Today, fishing, crabbing, crawdadding, and clamming are important recreation activities. Central Valley salmon—most raised in hatcheries—migrate through the Delta and support an economically and culturally important coastal fishery. In the Delta and its tributary rivers, recreational fishing for salmon, sturgeon, striped bass, largemouth bass, shad, and other fish attracts anglers from throughout California and the world. Fishing in the Delta is a centerpiece of the unique cultural, recreational, and natural heritage that makes the Delta a special place (see Chapter 5).

The use of hatcheries to breed fish and regulations to limit overfishing have long been important tools for aquatic resource management. But they carry their own risk. Hatcheries can allow interbreeding, weakening the genetic fitness of a fish species (Israel et al. 2011). Harvest of hatchery-enhanced fish stocks can pose additional risks to native species. Overfishing itself reduces genetic diversity. Fishing regulations generally protect fish from overharvest, but regulations can also help or hurt other fish species. For example, DFW recently proposed changes to striped bass sport fishing regulations to allow greater harvest of striped bass in the hopes of reducing bass predation on native fish, especially salmon. These changes were rejected by the Fish and Game Commission, but it is likely other regulations will be recommended, particularly as the emphasis on saving native fish from nonnative invasives continues. Future proposals should be based on an improved understanding of anglers' behavior as well as a better understanding of the likely response in populations of striped bass and other predators. Harvest regulations and management practices must consider broader effects on nontarget species, including other predators, and the ecosystem.

Striped bass, for example, are not the only animals that prey on salmon. Predators are natural parts of any ecosystem, and predation is a basic ecosystem process. Fish predators in the Delta include many water birds, mammals, and fish such as native pikeminnows and introduced largemouth bass, smallmouth bass, striped bass, catfish, and other species. Nonnative fish consume salmon and other species of concern in the Delta and its tributaries (Lindley and Mohr 2003). Acoustic tagging studies in the San Joaquin River and southern Delta suggest significant predation on hatchery-reared salmon smolts. Survival of tagged salmon smolts released in the lower San Joaquin River was estimated to be only 5 percent in 2010, with much of the loss attributed to predation (San Joaquin River Group Authority 2010). However, despite the evidence of locally high predation, the overall contribution of predation to the decline of salmon, steelhead, and smelt populations is not clear, and the effect of predator controls will remain uncertain without additional study.

Hatchery Management

Another important tool for harvest management is raising fish in hatcheries, later to be released into natural waterways.

In California, hatcheries are particularly important to compensate for dams that block migration routes for salmon and steelhead (see previous Ecosystem Restoration section). The first salmon hatchery in the state was on the McCloud River. Today, California hosts two federal and twenty-one State hatcheries for salmon, steelhead, or trout. In recent years, "conservation hatcheries" for various threatened and endangered species were considered to prevent extinction of a species while restoration and stressor reduction activities are under way.

Hatcheries are important tools, but they involve genetic and ecological risks:

- **Genetic risks.** Human intervention in the rearing of wild animals has the potential to cause genetic change in fish such as salmon (Israel et al. 2011). These changes can impact fish diversity and the health of fish populations. Inbreeding in a fish hatchery can occur when a limited stock is used at the hatchery. Inbreeding can affect the survival, growth, and reproduction of fish. Ironically, conditions in the hatchery may favor fish that best survive in hatchery, not natural, environments. When released, hatchery-produced fish mix with naturally spawned fish, resulting in a lower survival rate once fish are released into rivers and streams. Finally, loss of genetic diversity is a documented effect of overfishing (Holmes 2011), which some have suggested is encouraged by the use of hatchery fish.

- **Ecological risks.** Wild and hatchery fish of the same species often compete in nature. For example, wild and hatchery-reared Chinook salmon share the same habitat and diet. Hatchery-released salmon are larger than wild salmon, resulting in possible predation on wild salmon of the same age. Hatchery production of salmon masks the decline of wild salmon, contributes to the genetic dilution and loss of wild salmon, and increases competition for limited freshwater and ocean resources on which wild salmon depend (McGinnis 1994). Throughout the world, overfishing has led to collapsing fish stocks and food web disruptions (Pauly et al. 1998). Hatchery and harvest effects often also interact. Harvest of salmon from waters where both hatchery and wild fish occur has put wild salmon and steelhead at risk (Lackey 2003). Wild salmon mortalities occur even with controlled fishing regulations. A portion of all fish released after being hooked and caught do not survive. Capture methods such as use of barbless hooks and use of landing nets can help reduce mortality of released fish.

Hatcheries and harvest are not the root problem of species declines in the Delta and Central Valley (DFG and NMFS 2001). Despite considerable fishing pressure in the first part of the twentieth century, striped bass, salmon, and steelhead remained abundant in California. Large declines followed the construction of dams on almost all Central Valley rivers, which greatly reduced access to spawning and rearing habitat. Once fish populations are low and habitat is damaged, their harvest can be an especially important control factor. Hatcheries were intended to substitute for lost spawning and rearing habitat, but nature cannot be so easily mimicked. Artificial propagation can provide abundant fish for restocking, but it cannot replace the abundance, productivity, life history diversity, and broad distribution of viable populations. Successful hatchery propagation will work best if it goes hand in hand with habitat restoration. Ultimately, fish produced in hatcheries must thrive and naturally reproduce once they have left the hatchery (Israel et al. 2011). Accordingly, close attention needs to be paid to genetic management to reduce genetic risks.

Hatchery and harvest regulations, and management practices related to those regulations must be based on the best available science and follow adaptive management protocols for monitoring and evaluating the results. Evaluations of hatchery fish impacts would be aided by better hatchery fish-marking techniques and more extensive marking.

POLICIES AND RECOMMENDATIONS

Policies and recommendations for restoring the Delta ecosystem include the following core strategies to reduce the impact of ecosystem stressors:

- Create more natural functional Delta flows
- Restore habitat
- Improve water quality to protect the ecosystem
- Prevent introduction of and manage nonnative species impacts
- Improve hatcheries and harvest management

Success of Delta ecosystem restoration depends on considering and addressing all stressor categories as well as completing and implementing the BDCP described in Chapter 3. Because reducing or eliminating some stressors, especially the globally determined and legacy stressors, will be difficult, adaptation to unmitigable stressors is also imperative.

Create More Natural Functional Flows

Water flow in the Delta is critically important because flow affects the reliability of water supplies and the health of the Delta ecosystem. The best available science demonstrates that flow management is essential to restoration of the Delta ecosystem. Several important ecosystem stressors, including entrainment, are linked to altered water flows. Greater reverse flows in the south Delta increase the numbers of fish entrained.

Problem Statement

Altered flows in the Sacramento and San Joaquin rivers and their tributaries change flows within and out of the Delta, and affect salinity and sediment in the Delta. Fish and other aquatic species native to the Delta are adapted to natural flow, salinity, and sediment regimes. Current flow, salinity, and sediment regimes harm native aquatic species and encourage nonnative species. The best available science suggests that currently required flow objectives within and out of the Delta are insufficient to protect the Delta ecosystem (SWRCB 2010). Additionally, uncertainty regarding future flow objectives for the Delta impairs the reliability of water supplies that depend on the Delta or its watershed. The predictability of water exports cannot be improved, and the BDCP cannot be implemented without timely SWRCB action to update flow objectives.

Policy

ER P1. Delta Flow Objectives

(a) *The State Water Resources Control Board's Bay Delta Water Quality Control Plan flow objectives shall be used to determine consistency with the Delta Plan. If and when the flow objectives are revised by the State Water Resources Control Board, the revised flow objectives shall be used to determine consistency with the Delta Plan.*

(b) *For purposes of Water Code section 85057.5(a)(3) and section 5001(j)(1)(E) of this Chapter, the policy set forth in subsection (a) covers a proposed action that could significantly affect flow in the Delta.*

23 CCR Section 5005
NOTE: Authority cited: Section 85210(i), Water Code.
Reference: Sections 85020, 85054, 85086, 85087, 85300, and 85302, Water Code.

Recommendations

ER R1. Update Delta Flow Objectives

Development, implementation, and enforcement of new and updated flow objectives for the Delta and high-priority tributaries are key to the achievement of the coequal goals. The State Water Resources Control Board should update the Bay Delta Water Quality Control Plan objectives as follows:

(a) *By June 2, 2014, adopt and implement updated flow objectives for the Delta that are necessary to achieve the coequal goals.*

(b) *By June 2, 2018, adopt, and as soon as reasonably possible, implement flow objectives for high-priority tributaries in the Delta watershed that are necessary to achieve the coequal goals.* [1]

[1] SWRCB staff should work with the Council and DFW to determine priority streams. As an illustrative example, priority streams could include the Merced River, Tuolumne River, Stanislaus River, Lower San Joaquin River, Deer Creek (tributary

Flow objectives could be implemented through several mechanisms including negotiation and settlement, Federal Energy Regulatory Commission relicensing, or adjudicative proceeding. [2]

Prior to the establishment of revised flow objectives identified above, the existing Bay Delta Water Quality Control Plan objectives shall be used to determine consistency with the Delta Plan. After the flow objectives are revised, the revised objectives shall be used to determine consistency with the Delta Plan.

Restore Habitat

Loss of habitat is one of the largest stressors to the Delta ecosystem. The Delta Plan adopts the approach of the multiagency ERP Conservation Strategy (DFG 2011), which includes a map and accompanying text identifying appropriate habitat restoration types within the Delta and Suisun Marsh based on land elevation, included in the Delta Plan within Appendix B. Delta Plan Figure 4-6 is based on the ERP Conservation Strategy map. Policy ER P3 requires habitat restoration actions to use this figure and accompanying text (see Appendix B for additional information). For example, restoring tidal marsh habitat would generally not be appropriate outside the areas labeled "intertidal" on Figure 4-6 unless they connect other tidal marshes into large habitat areas or can recover elevation over time by natural processes.

An integrated, adaptive approach to restoring habitat must address several issues. Each problem statement below highlights one of these issues, followed by specific policies and recommendations intended to address it.

Problem Statement

Features of the Delta landscape, particularly the condition of its waterways, the elevation of its land, and other environmental conditions, have changed dramatically over the past 160 years. Damage to the habitats that support native species in the Delta has led to declines in native animal and plant populations, affecting both resident and migratory species.

Policies

The appendices referred to in the policy language below are included in Appendix B of the Delta Plan.

ER P2. Restore Habitats at Appropriate Elevations

(a) *Habitat restoration must be carried out consistent with Appendix 3, which is Section II of the* Draft Conservation Strategy for Restoration of the Sacramento-San Joaquin Delta Ecological Management Zone and the Sacramento and San Joaquin Valley Regions *(California Department of Fish and Wildlife 2011). The elevation map attached as Appendix 4 should be used as a guide for determining appropriate habitat restoration actions based on an area's elevation. If a proposed habitat restoration action is not consistent with Appendix 4, the proposal shall provide rationale for the deviation based on best available science.*

(b) *For purposes of Water Code section 85057.5(a)(3) and section 5001(j)(1)(E) of this Chapter, this policy covers a proposed action that includes habitat restoration.*

23 CCR Section 5006
NOTE: Authority cited: Section 85210(i), Water Code.
Reference: Sections 85020, 85022, 85054, 85300, and 85302, Water Code.

ER P3. Protect Opportunities to Restore Habitat

(a) *Within the priority habitat restoration areas depicted in Appendix 5, significant adverse impacts to the opportunity to restore habitat as described in section 5006, must be avoided or mitigated.*

(b) *Impacts referenced in subsection (a) will be deemed to be avoided or mitigated if the project is designed and implemented so that it will not preclude or otherwise interfere with the ability to restore habitat as described in section 5006.*

(c) *Impacts referenced in subsection (a) shall be mitigated to a point where the impacts have no significant effect on the opportunity to restore habitat as described in section 5006. Mitigation shall be determined, in consultation with the California Department of Fish and Wildlife, considering the size of the area impacted by the covered action and the type and value of habitat that could be restored on that area, taking into account existing and proposed restoration plans, landscape attributes, the elevation map shown in Appendix 4, and other relevant information about habitat restoration opportunities of the area.*

(d) *For purposes of Water Code section 85057.5(a)(3) and section 5001(j)(1)(E) of this Chapter, this policy covers proposed actions in the priority habitat restoration areas depicted in Appendix 5. It does not cover proposed actions outside those areas.*

to Sacramento River), Lower Butte Creek, Mill Creek (tributary to Sacramento River), Cosumnes River, and American River. Implementation through hearings is expected to take longer than the deadline shown here.

[2] Implementation through adjudicative proceedings or FERC relicensing is expected to take longer than the deadline shown here.

23 CCR Section 5007
NOTE: Authority cited: Section 85210(i), Water Code.
Reference: Sections 85020, 85022, 85054, 85300, 85302, and 85305, Water Code.

Figure 4-7 provides examples of ways a project can implement ER P3.

ER P4. Expand Floodplains and Riparian Habitats in Levee Projects

(a) Levee projects must evaluate and where feasible incorporate alternatives, including the use of setback levees, to increase floodplains and riparian habitats. Evaluation of setback levees in the Delta shall be required only in the following areas (shown in Appendix 8): (1) The Sacramento River between Freeport and Walnut Grove, the San Joaquin River from the Delta boundary to Mossdale, Paradise Cut, Steamboat Slough, Sutter Slough; and the North and South Forks of the Mokelumne River, and (2) Urban levee improvement projects in the cities of West Sacramento and Sacramento.

(b) For purposes of Water Code section 85057.5(a)(3) and section 5001(j)(1)(E) of this Chapter, this policy covers a proposed action to construct new levees or substantially rehabilitate or reconstruct existing levees.

23 CCR Section 5008
NOTE: Authority cited: Section 85210(i), Water Code.
Reference: Sections 85020, 85022, 85054, 85300, 85302, and 85305, Water Code.

Recommendations

ER R2. Prioritize and Implement Projects that Restore Delta Habitat

Bay Delta Conservation Plan implementers, California Department of Fish and Wildlife, California Department of Water Resources, and the Delta Conservancy should prioritize and implement habitat restoration projects in the areas shown on Figure 4-8. Habitat restoration projects should ensure connections between areas being restored and existing habitat areas and other elements of the landscape needed for the full life cycle of the species that will benefit from the restoration project. Where possible, restoration projects should also emphasize the potential for improving water quality. Restoration project proponents should consult the California Department of Public Health's Best Management Practices for Mosquito Control in California.

How Projects Can Comply with ER P3

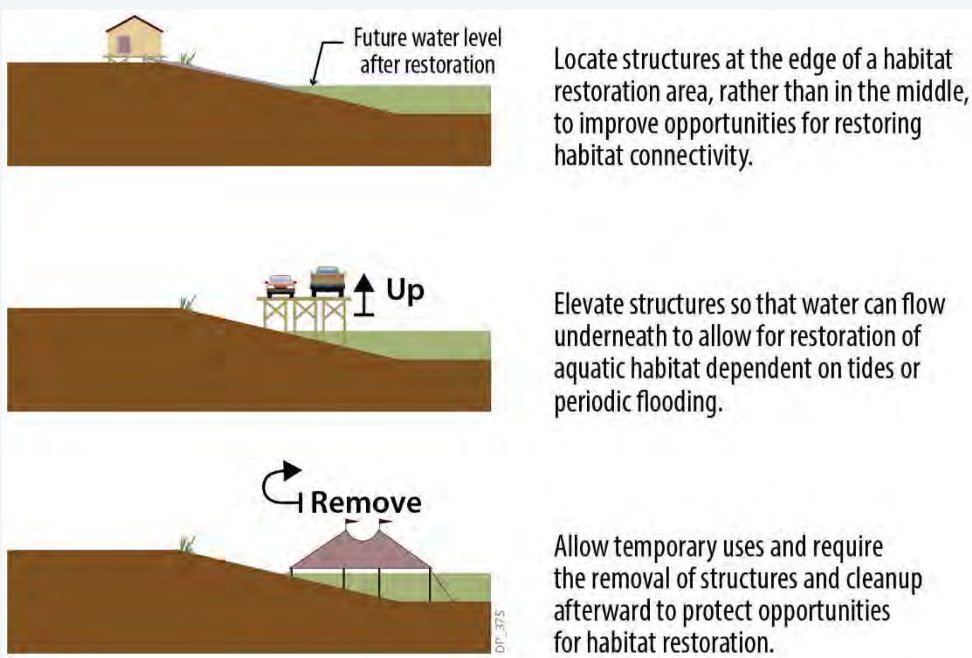


Figure 4-7 ER P3 requires projects located in the priority habitat restoration areas (shown on Figure 4-8) to protect opportunities to restore habitat. This figure shows conceptual examples of how to implement this policy.

Recommended Areas for Prioritization and Implementation of Habitat Restoration Projects

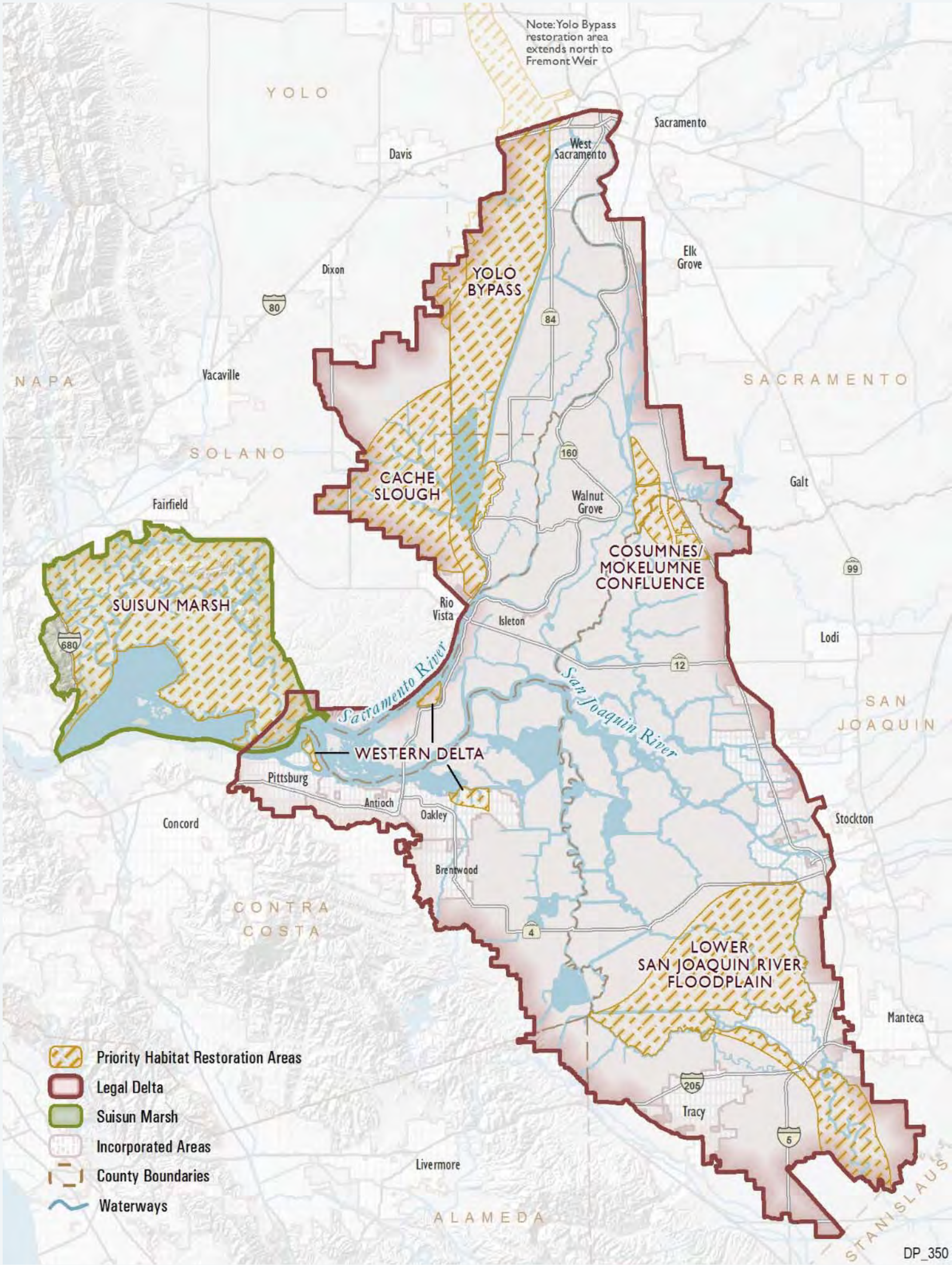


Figure 4-8 Priority habitat restoration areas are large areas within which specific sites may be identified for habitat restoration based on assessments of land use and other issues addressed through further feasibility analysis.

Source: DFG 2011

- ***Yolo Bypass.*** *Enhance the ability of the Yolo Bypass to flood more frequently to provide more opportunities for migrating fish, especially Chinook salmon, to use this system as a migration corridor that is rich in cover and food.*
- ***Cache Slough Complex.*** *Create broad nontidal, freshwater, emergent-plant-dominated wetlands that grade into tidal fresh-water wetlands, and shallow subtidal and deep open-water habitats. Also, return a significant portion of the region to uplands with vernal pools and grasslands.*
- ***Cosumnes River–Mokelumne River confluence.*** *Allow these unregulated and minimally regulated rivers to flood over their banks during winter and spring frequently and regularly to create seasonal floodplains and riparian habitats that grade into tidal marsh and shallow subtidal habitats.*
- ***Lower San Joaquin River floodplain.*** *Reconnect the floodplain and restore more natural flows to stimulate food webs that support native species. Integrate habitat restoration with flood management actions, when feasible.*
- ***Suisun Marsh.*** *Restore significant portions of Suisun Marsh to brackish marsh with land-water interactions to support productive, complex food webs to which native species are adapted and to provide space to adapt to rising sea level action. Use information from adaptive management processes during the* Suisun Marsh Habitat Management, Preservation, and Restoration Plan's *implementation to guide future habitat restoration projects and to inform future tidal marsh management.*
- ***Western Delta/Eastern Contra Costa County.*** *Restore tidal marsh and channel margin habitat at Dutch Slough and western islands to support food webs and provide habitat for native species.*

ER R3. Complete and Implement Delta Conservancy Strategic Plan

As part of its Strategic Plan and subsequent Implementation Plan or annual work plans, the Delta Conservancy should:

- *Develop and adopt criteria for prioritization and integration of large-scale ecosystem restoration in the Delta and Suisun Marsh, with sustainability and use of best available science as foundational principles.*
- *Develop and adopt processes for ownership and long-term operations and management of land in the Delta and Suisun Marsh acquired for conservation or restoration.*
- *Develop and adopt a formal mutual agreement with the California Department of Water Resources, California Department of Fish and Wildlife, federal interests, and other State and local agencies on implementation of ecosystem restoration in the Delta and Suisun Marsh.*
- *Develop, in conjunction with the Wildlife Conservation Board, the California Department of Water Resources, California Department of Fish and Wildlife, Bay Delta Conservation Plan implementers, and other State and local agencies, a plan and protocol for acquiring the land necessary to achieve ecosystem restoration consistent with the coequal goals and the Ecosystem Restoration Program Conservation Strategy.*
- *Lead an effort, working with State and federal fish agencies, to investigate how to better use habitat credit agreements to provide credit for each of these steps: (1) acquisition for future restoration; (2) preservation, management, and enhancement of existing habitat; (3) restoration of habitat; and (4) monitoring and evaluation of habitat restoration projects.*
- *Work with the California Department of Fish and Wildlife and the U.S. Fish and Wildlife Service to develop rules for voluntary safe harbor agreements with property owners in the Delta whose actions contribute to the recovery of listed threatened or endangered species.*

Problem Statement

Current USACE policy requires removal of vegetation from Delta levees, which would reduce already sparse riparian and shaded aquatic habitat along the channels.

Policies

No policies with regulatory effect are included in this section.

Recommendation

ER R4. Exempt Delta Levees from the U.S. Army Corps of Engineers' Vegetation Policy

Considering the ecosystem value of remaining riparian and shaded riverine aquatic habitat along Delta levees, the U.S. Army Corps of Engineers should agree with the California Department of Fish and Wildlife and the California Department of Water Resources on a variance that exempts Delta levees from the U.S. Army Corps of Engineers' levee vegetation policy where appropriate.

Problem Statement

The SMPP and the Local Protection Program components of the SMPP do not yet include climate change provisions. Without these amendments, it is unclear if and how Suisun Marsh will be managed to adapt to rising sea level.

Policies

No policies with regulatory effect are included in this section.

Recommendation

ER R5. Update the Suisun Marsh Protection Plan

The San Francisco Bay Conservation and Development Commission should update the Suisun Marsh Protection Plan *and relevant components of the Suisun Marsh Local Protection Program to adapt to sea level rise and ensure consistency with the Suisun Marsh Preservation Act, the Delta Reform Act, and the Delta Plan.*

Improve Water Quality to Protect the Ecosystem

Chapter 6 includes recommendations about salinity and ecosystem water quality. These recommendations support the protection of water quality for all beneficial uses of water and encourage the identification of water quality impacts of proposed actions. The recommendations also address acceleration of certain total maximum daily loads, low dissolved oxygen, implementation of a Delta Regional Monitoring Program, treatment of wastewater effluent and urban runoff, and Regional Water Quality Control Board engagement in Suisun Marsh.

Problem Statement

The Delta ecosystem is impaired by pollutants from municipal, industrial, agricultural, and other discharges and legacy pollutants flowing into the Delta and its tributaries, including pollutants that bioaccumulate and biomagnify in the food web.

Policies

No policies with regulatory effect are included in this section.

Recommendations

Recommendations for improving ecosystem water quality are included in Chapter 6.

Prevent Introduction of and Manage Nonnative Species Impacts

Problem Statement

Nonnative species are a major obstacle to successful restoration of the Delta ecosystem because they affect the survival, health, and distribution of native Delta wildlife and plants. There is little chance of eradicating most established nonnative species, but management can reduce the abundance of some. The resilience of native species is reduced by ongoing introductions of nonnative species and management actions that enhance conditions for nonnative species.

Policy

ER P5. Avoid Introductions of and Habitat Improvements for Invasive Nonnative Species

(a) The potential for new introductions of or improved habitat conditions for nonnative invasive species, striped bass, or bass must be fully considered and avoided or mitigated in a way that appropriately protects the ecosystem.

(b) For purposes of Water Code section 85057.5(a)(3) and section 5001(j)(1)(E) of this Chapter, this policy covers a proposed action that has the reasonable probability of introducing or improving habitat conditions for nonnative invasive species.

23 CCR Section 5009
NOTE: Authority cited: Section 85210(i), Water Code.
Reference: Sections 85020, 85054, 85300, and 85302, Water Code.

Recommendations

ER R6. Regulate Angling for Nonnative Sport Fish to Protect Native Fish

The California Department of Fish and Wildlife should develop, for consideration by the Fish and Game Commission, proposals for new or revised fishing regulations designed to increase populations of listed fish species through reduced predation by introduced sport fish. The proposals should be based on sound science that demonstrates these *management actions are likely to achieve their intended outcome and include the development of performance measures and a monitoring plan to support adaptive management.*

ER R7. Prioritize and Implement Actions to Control Nonnative Invasive Species

The California Department of Fish and Wildlife and other appropriate agencies should prioritize and fully implement the list of "Stage 2 Actions for Nonnative Invasive Species" and accompanying text shown in Appendix J taken from the Conservation Strategy for Restoration of the Sacramento–San Joaquin Delta Ecological Management Zone and the Sacramento and San Joaquin Valley Regions *(DFG 2011). Implementation of the Stage 2 actions should include the development of performance measures and monitoring plans to support adaptive management.*

Improve Hatcheries and Harvest Management

Problem Statement

Hatcheries and harvest regulation are important tools in fisheries management, but they also pose genetic and ecological risks to native species and the Delta ecosystem. These practices need to employ adaptive management strategies to predict and evaluate outcomes, and minimize risks.

Policies

No policies with regulatory effect are included in this section.

Recommendations

ER R8. Manage Hatcheries to Reduce Genetic Risk

As required by the National Marine Fisheries Service, all hatcheries providing listed fish for release into the wild should continue to develop and implement scientifically sound Hatchery and Genetic Management Plans (HGMPs) to reduce risks to those species. The California Department of Fish and Wildlife should provide annual updates to the Delta Stewardship Council on the status of HGMPs within its jurisdiction.

ER R9. Implement Marking and Tagging Program

By December 2014, the California Department of Fish and Wildlife, in cooperation with the U.S. Fish and Wildlife Service and the National Marine Fisheries Service, should revise and begin implementing its program for marking and tagging hatchery salmon and steelhead to improve management of hatchery and wild stocks based on recommendations of the California Hatchery Scientific Review Group, which considered mass marking, reducing hatchery programs, and mark selective fisheries in developing its recommendations.

Timeline for Implementing Policies and Recommendations

Figure 4-9 lays out a timeline for implementing the policies and recommendations described in the previous section. The timeline emphasizes near-term and intermediate-term actions.

Timeline for Implementing Policies and Recommendations

TIMELINE CHAPTER 4: Ecosystem Implementation

	ACTION (REFERENCE #)	LEAD AGENCY(IES)	NEAR TERM 2012–2017	INTERMEDIATE TERM 2017–2025
POLICIES	Delta flow objectives (ER P1)	SWRCB	●	●
	Restore habitats at appropriate elevations (ER P2)	DFW, DWR, Delta Conservancy	●	●
	Protect opportunities to restore habitat (ER P3)	DFW	●	●
	Expand floodplains and riparian habitats in levee projects (ER P4)	DWR, USACE	●	●
	Avoid introductions of and habitat improvements for invasive nonnative species (ER P5)	DFW, DWR, Delta Conservancy	●	●
RECOMMENDATIONS	Update Delta flow objectives (ER R1)	SWRCB	●	●
	Prioritize and implement projects that restore Delta habitat (ER R2)	DFW, DWR, and Delta Conservancy	●	●
	Complete and implement Delta Conservancy Strategic Plan (ER R3)	Delta Conservancy	●	
	Exempt Delta levees from U.S. Army Corps of Engineers' Vegetation Policy (ER R4)	USACE, DWR, DFW	●	●
	Update the Suisun Marsh Protection Plan (ER R5)	BCDC	●	
	Regulate angling for nonnative sport fish to protect native fish (ER R6)	DFW, CA Fish and Game Commission	●	
	Prioritize and implement actions to control nonnative invasive species (ER R7)	DFW	●	●
	Manage hatcheries to reduce genetic risk (ER R8)	DFW	●	●
	Implement marking and tagging program (ER R9)	DFW	●	●

DP_343

Agency Key:

BCDC: San Francisco Bay Conservation and Development Commission
BDCP: Bay Delta Conservation Plan
Delta Conservancy: Sacramento-San Joaquin Delta Conservancy
Council: Delta Stewardship Council
DFW: California Department of Fish and Wildlife
DWR: California Department of Water Resources
RWQCB: Regional Water Quality Control Board(s)
SWRCB: State Water Resources Control Board
USACE: U.S. Army Corps of Engineers

Figure 4-9

Issues for Future Evaluation and Coordination

Additional areas of interest and concern related to the Delta ecosystem may deserve consideration in the development of future Delta Plan updates:

- **Landscape-scale conceptual models.** The Delta Science Program will collaborate with other agencies, academic institutions, and stakeholders to develop landscape-scale conceptual models for the six priority restoration areas identified in ER R2.
- **Workshops to address stressor impacts.** The Delta Science Program, in collaboration with other agencies, academic institutions, and stakeholders, will hold workshops to develop additional recommendations to the Council for measures to reduce stressor impacts on the Delta ecosystem that would support and be consistent with the coequal goals. Recommended measures could be adopted as policies or recommendations by the Council into an amended Delta Plan.
- **Above-the-Delta migration corridors.** The Council will consult with fish and wildlife agencies and others as they complete or update plans to restore habitats for migratory species, such as anadromous fish or songbirds in the Sacramento and San Joaquin valleys above the Delta.

Science and Information Needs

The Delta ecosystem is not static; therefore, additional information is needed for decision making and adaptive management. Specifically, the following information is needed in the following areas:

- Landscape-scale conceptual models for Delta ecosystem restoration.
- Assessment of how flows benefit or harm native wildlife and plants.
- Effects of changing habitat quality and quantity on Delta fish and invertebrates. Examples might include (1) threadfin shad in the south and central Delta, (2) comparison of shallow shoal habitat and deep channel habitat to food resources of young striped bass, and (3) relationship between water turbidity and native fish migration, survival, growth, and/or reproduction.
- Hatchery, harvest, and/or predation impacts on natural fish populations.
- Tools to assess native fish response to restored habitats.
- Entrainment effects on fish populations.
- Tools to assess potential impacts of climate change and sea level rise to viability of species in intertidal habitats.

Performance Measures

Development of informative and meaningful performance measures is a challenging task that will continue after the adoption of the Delta Plan. Performance measures need to be designed to capture important trends and to address whether specific actions are producing expected results. Efforts to develop and track performance measures in complex and large-scale systems like the Delta are commonly multiyear endeavors. The recommended output and outcome performance measures listed below are provided as examples and subject to refinement as time and resources allow. Final administrative performance measures are listed in Appendix E and will be tracked as soon as the Delta Plan is completed.

The Delta Reform Act specifies some performance measures for large-scale ecosystem restoration within the Delta. Ecosystem performance measures should address progress in achieving the objectives set forth in Water Code sections 85302(c) and 85302(e).

Note that performance measures for ecosystem water quality are provided in Chapter 6.

Output Performance Measures

- The SWRCB adopts Delta flow objectives by June 2, 2014. (ER R1)
- The SWRCB adopts flow objectives for the major tributaries by 2018 (or soon as reasonably possible). (ER R1)
- Pilot-scale Delta habitat restoration projects are developed and initiated in the priority areas described in ER R2 by 2015. These projects include tidal brackish and freshwater marsh as well as floodplain restoration, and have clear adaptive management plans aimed at improving outcomes and providing lessons for the development of large-scale restoration projects. Metrics: acres restored by habitat type, and lessons learned. (ER R2)
- Progress, measured in acres of restored or enhanced habitat, is being made toward the biological opinions' targets of restoring 8,000 acres of tidal marsh and 17,000 to 20,000 acres of floodplain rearing habitat. (ER R2)
- The DFW and other appropriate agencies fully implement the list of "Stage 2 Actions for Nonnative Invasive Species." (ER R7)

Outcome Performance Measures

- Progress toward restoring in-Delta flows to more natural functional flow patterns to support a healthy estuary. Metrics: results from hydrological monitoring and hydrodynamic modeling. (ER R1)
- Progress toward decreasing annual trends in both the number of new and existing aquatic and terrestrial nonnative species, and the abundance and distribution of existing aquatic and terrestrial nonnative species in the Delta over the next decade. These trends will be derived from long-term animal and plant monitoring surveys conducted by the Interagency Ecological Program agencies, the California Department of Boating and Waterways, the U.S. Department of Agriculture, the San Francisco Estuary Institute, and others. (ER P5)
- Progress toward the documented occurrence and use of protected and restored habitats and migratory corridors by native resident and migratory Delta species. Trends in occurrence, use, and performance of native species in protected and restored habitats and corridors will be upward over the next decade. These trends will be derived from animal and plant monitoring surveys that are conducted as part of adaptive management strategies for the protection and restoration of these areas. (ER R2)
- Progress toward achieving the State and federal "doubling goal" for wild Central Valley salmonids relative to 1995 levels. Trends will be derived from long-term salmonid monitoring surveys conducted by the National Marine Fisheries Service, U.S. Fish and Wildlife Service, and others. (ER R2)

References

Baxter, R., R. Breuer, L. Brown, L. Conrad, F. Feyrer, S. Fong, K. Gehrts, L. Grimaldo, B. Herbold, P. Hrodey, A. Mueller-Solger, T. Sommer, and K. Souza. 2010. *Interagency Ecological Program 2010 Pelagic Organism Decline Work Plan and Synthesis of Results*. Interagency Ecological Program for the San Francisco Estuary.

BDCP (Bay Delta Conservation Plan). 2012. *Bay Delta Conservation Plan Administrative Draft*, Chapter 3 Conservation Strategy (Section 3.3). February 2012.

BDCP Independent Science Advisors. 2007. *Independent Science Advisor's Report*. November 16.

Breitburg, D. L., B. C. Crump, J. O. Dabiri, and C. L. Gallegos. 2010. Ecosystem engineers in the pelagic realm: Alteration of habitat by species ranging from microbes to jellyfish. *Integrative and Comparative Biology* 50: 188–200.

Brown, L. R., and D. Michniuk. 2007. Littoral fish assemblages of the alien-dominated Sacramento-San Joaquin Delta, California, 1980-1983 and 2001-2003. *Estuaries and Coasts* 30:186-200.

Bunn, S. E., and A. H. Arthington. 2002. Basic principles and ecological consequences of altered flow regimes for aquatic biodiversity. *Environmental Management* 30:492-507.

California Natural Resource Agency. 2009. *California Climate Adaptation Strategy*. 200 pp. http://resources.ca.gov/climate_adaptation/docs/Statewide_Adaptation_Strategy.pdf.

California Ocean Protection Council. 2011. *Resolution of the California Ocean Protection Council on Sea Level Rise*. Adopted March 11.

Carlisle, D. M., D. M. Wolock, and M. R. Meador. 2010. Alteration of streamflow magnitudes and potential ecological consequences: a multiregional assessment. *Frontiers in Ecology and the Environment* 9(5): 264-270.

Claudi, R., and H. Leach (eds.). 2000. *Nonindigenous Freshwater Organisms: Vectors, Biology, and Impacts*. Lewis Publishers. Boca Raton, Florida. pp. 127-147.

Cloern, J. E. 2007. Habitat connectivity and ecosystem productivity: implications from a simple model. *The American Naturalist* 169:E21-E33.

Cohen, A. N., and J. T. Carlton. 1998. Accelerating invasion rate in a highly invaded estuary. *Science* 279:555-558.

Crain, P. K., K. Whitener, and P. B. Moyle. 2004. Use of a restored central California floodplain by larvae of native and alien fishes. In Feyrer, F., L. R. Brown, R. L. Brown, and J. J. Orsi, (eds.), *Early Life History of Fishes in the San Francisco Estuary and Watershed*. American Fisheries Society Symposium 39. Bethesda, Maryland. pp. 125–140.

Delta ISB (Independent Science Board). 2011. Memorandum to Phil Isenberg, Chair, Delta Stewardship Council, and Members of the Delta Stewardship Council: Addressing Multiple Stressors and Multiple Goals in the Delta Plan. January 26. 15pp.

DFG and NMFS (California Department of Fish and Game and National Marine Fisheries Service). 2001. *Final Report on Anadromous Salmonid Fish Hatcheries in California*. Final Review Draft. December 3.

DFG (California Department of Fish and Game). 2008. *California Aquatic Invasive Species Management Plan*. January.

DFG (California Department of Fish and Game). 2011. *Conservation Strategy for Restoration of the Sacramento-San Joaquin Delta Ecological Management Zone and the Sacramento and San Joaquin Valley Regions*. Draft. July.

DFG (California Department of Fish and Game). 2012. Comment letter on Final Staff Draft Delta Plan. June 13.

DWR (California Department of Water Resources). 2003. California Central Valley unimpaired flow data, fourth edition. Bay-Delta office. November 2006.

Enright, C., and S. D. Culberson. 2010. Salinity trends, variability, and control in the northern reach of the San Francisco Estuary. *San Francisco Estuary and Watershed Science* 7(2). http://escholarship.org/uc/item/0d52737t.

FEMA (Federal Emergency Management Agency). 2005. *Technical Manual for Dam Owners, Impacts of Plants on Earthen Dams*. FEMA-534. pp. 115.

Feyrer, F. 2004. Ecological segregation of native and alien larval fish assemblages in the southern Sacramento-San Joaquin Delta. In Feyrer, F., L. R. Brown, R. L. Brown, and J. J. Orsi, (eds.), *Early Life History of Fishes in the San Francisco Estuary and Watershed*. American Fisheries Society Symposium 39. Bethesda, Maryland, pp.67–79.

Feyrer, F., and M. P. Healy. 2003. Fish community structure and environmental correlates in the highly altered southern Sacramento-San Joaquin Delta. *Environmental Biology of Fishes* 66:123–132.

Feyrer, F., M. L. Nobriga, and T. R. Sommer. 2007. Multidecadal trends for three declining fish species: habitat patterns and mechanisms in the San Francisco Estuary, California, USA. *Canadian Journal of Fisheries and Aquatic Sciences* 64:723–734.

Foley, J. A., R. DeFries, G. P. Asner, C. Barford, G. Bonan, S. R. Carpenter, et al. 2005. Global consequences of land use. *Science* 309:570–574.

Grimaldo, L. F., R. E. Miller, C. P. Peregrin, and Z. P. Hymanson. 2004. Spatial and temporal distribution of native and alien ichthyoplankton in three habitat types of the Sacramento-San Joaquin Delta. *American Fisheries Society Symposium* 39:81-96.

Grimaldo, L. F., T. Sommer, N. V. Ark, G. Jones, E. Holland, P. B. Moyle, B. Herbold, and P. Smith. 2009. Factors affecting fish entrainment into massive water diversions in a tidal freshwater estuary: can fish losses be managed? *North American Journal of Fisheries Management* 29:1253-1270.

Grossinger, R. M., A. A. Whipple, J. C. Collins, and D. Rankin. 2010. Historical Delta landscapes: Conceptual models for building a diverse and resilient future. Bay Delta Science Conference.

Hall, L. S., P. A. Krausman, and M. L. Morrison. 1997. The habitat concept and a plea for the use of standard terminology. *Wildlife Society Bulletin* 25:173–182.

Hanak, E., J. Lund, A. Dinar, B. Gray, R. Howitt, J. Mount, P. Moyle, and B. Thompson. 2011. *Managing California's Water: From Conflict to Reconciliation*. Public Policy Institute of California: San Francisco, California. 482 pp.

Hannon, S. J., and F. Schmiegelow. 2002. Corridors may not improve the conservation value of small reserves for most boreal birds. *Ecological Applications* 12:1457–1468.

Healey, Michael. 2007a. Delta Vision Context Memorandum: Delta Ecological Principles. http://deltavision.ca.gov/BlueRibbonTaskForce/July2007/PostMtg/Day_1_Item_5_Handout_2.pdf.

Healey, Michael. 2007b. Design Principles for a Sustainable Ecosystem in the Bay-Delta. http://deltavision.ca.gov/BlueRibbonTaskForce/Oct2007/PostMtg/Item_6_Handout1.pdf.

Healey, M. C., M. D. Dettinger, and R. B. Norgaard, eds. 2008. *The State of Bay-Delta Science, 2008*. Abstract. CALFED Science Program: Sacramento, California. 174 pp.

Hermoso, V., F. Pantus, J. Olley, S. Linke, J. Mugodo, and P. Lea. 2012. Systematic planning for river rehabilitation: integrating multiple ecological and economic objectives in complex decisions. *Freshwater Biology* 57:1–9.

Holmes, B. 2011. Overfishing eats away at genetic diversity of fish. *New Scientist*. http://www.newscientist.com/article/dn20699-overfishing-eats-away-at-genetic-diversity-of-fish.html. July 15.

Israel, J. A., K. M. Fisch, T. F. Turner, and R. S. Waples. 2011. Conservation of native fishes of the San Francisco Estuary: Considerations for artificial propagation of Chinook salmon, delta smelt, and green sturgeon. San Francisco Estuary and Watershed Science, John Muir Institute of the Environment, UC Davis.

Jassby, A. D., and J. E. Cloern. 2000. Organic matter sources and rehabilitation of the Sacramento-San Joaquin Delta (California, USA). *Aquatic Conservation: Marine and Freshwater Ecosystems* 10:323-352.

Jassby, A. D., W. J. Kimmerer, S. G. Monismith, C. Armor, J. E. Cloern, T. M. Powell, J. R. Schubel, and T. J. Vendlinski. 1995. Isohaline position as a habitat indicator for estuarine populations. *Ecological Applications* 5:272-289.

Jeffres, C. A., J. J. Opperman, and P. B. Moyle. 2008. Ephemeral floodplain habitats provide best growth conditions for juvenile Chinook salmon in a California river. E*nvironmental Biology of Fishes* 83(4): 449–458.

Jones, C. G., J. H. Lawton, and M. Shachak. 1994. Organisms as ecosystem engineers. *Oikos* 69:373–386.

Kimmerer, W. J. 2006. Response of anchovies dampens effects of the invasive bivalve *Corbula amurensis* on the San Francisco Estuary foodweb. *Marine Ecology Progress Series* 324:207–218.

Lackey, R. T. 2003. Pacific Northwest salmon: forecasting their status in 2100. *Reviews in Fisheries Science* 11(1): 35-88.

Lindenmayer, D., R. Hobbs, and J. Miller, et al. 2008. A checklist for ecological management of landscapes for conservation. *Ecology Letters* 11:78–91.

Lindley, S. T., and M. S. Mohr. 2003. Modeling the effect of striped bass (*Morone saxatilis*) on the population viability of Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*). National Marine Fisheries Service. Fish Bulletin 101:321–331.

Lotze, H. K., H. S. Lenihan, B. J. Bourque, R. H. Bradbury, R. G. Cooke, M. C. Kay, S. M. Kidwell, M. X. Kirby, C. H. Peterson, and J. B. C. Jackson. 2006. Depletion, degradation, and recovery potential of estuaries and coastal seas. *Science* 312:1806–1809.

McGinnis, M.V. 1994. The politics of restoring versus restocking in the Columbia River. *Restoration Ecology* 2(3): 149-155. http://www.nwfsc.noaa.gov/resources/salmonhatchery/risks.cfm#genetic.

Monsen, N. E., J. R. Cloern, and J. R. Burau. 2007. Effects of flow diversions on water and habitat quality: Examples from California's highly manipulated Sacramento-San Joaquin Delta. *San Francisco Estuary and Watershed Science* 5(3):1-16. http://escholarship.org/uc/item/04822861.

Moyle, P. B., P. K. Crain, and K. Whitener. 2007. Patterns in the use of a restored California floodplain by native and alien fishes. *San Francisco Estuary and Watershed Science* 5(3):1–27. http://repositories.cdlib.org/jmie/sfews/vol5/iss3/art1.

Moyle, P. B., W. A. Bennett, W. E. Fleenor, and J. R. Lund. 2010. Habitat variability and complexity in the upper San Francisco Estuary. *San Francisco Estuary and Watershed Science* 8(3):1-24. http://escholarship.org/uc/item/0kf0d32x.

Moyle, P. B., and J. F. Mount. 2007. Homogenized rivers, homogenized faunas. *Proceedings of the National Academy of Sciences* 104:5711-5712.Newman, K. B. 2008. *An Evaluation of Four Sacramento-San Joaquin River Delta Juvenile Salmon Survival Studies*. Stockton FWO, U.S. Fish and Wildlife Service.

NMFS (National Marine Fisheries Service). 2009. Biological Opinion and Conference Opinion on the Long Term Operations of the Central Valley Project and the State Water Project. http://swr.nmfs.noaa.gov/ocap/NMFS Biological and Conference Opinion on the Long Term Operations of the CVP and SWP.pdf.

Nobriga, M. L., and F. Feyrer. 2007. Shallow-water piscivore-prey dynamics in California's Sacramento-San Joaquin Delta. *San Francisco Estuary and Watershed Science* 5(2):1-15. http://escholarship.org/uc/item/387603c0.

Nobriga, M. L., F. Feyrer, R. D. Baxter, and M. Chotkowski. 2005. Fish community ecology in an altered river delta: Spatial patterns in species composition, life history strategies, and biomass. *Estuaries and Coasts* 28:776-785.

Oltmann, R. N. 1998. Measured flow and tracer-dye data showing anthropogenic effects on the hydrodynamics of south Sacramento-San Joaquin Delta, California, Spring 1996-1997. U.S. Geological Survey Open-File Report 98-285.

Palmer, M. A., E. S. Bernhardt, J. D. Allan, P. S. Lake, G. Alexander, S. Brooks, J. Carr, S. Clayton, C. N. Dahm, J. Follstad Shah, D. L. Galat, S. Gloss, P. Goodwin, D. H. Hart, B. Hassett, R. Jenkinson, G. M. Kondolf, R. Lave, J. L. Meyer, T. K. O'Donnell, L. Pagano, P. Srivastava, and E. Sudduth. 2005. Standards for ecologically successful river restoration. *Journal of Applied Ecology* 42:208–217.

Pauly, D., V. Christensen, J. Dalsgaard, R. Froese, and F. Torres Jr. 1998. Fishing down marine food webs. *Science* 279:860-863.

Perry, R. W., J. R. Skalski, P. L. Brandes, P. T. Sandstrom, A. P. Klimley, A. Ammann, and B. Macfarlane. 2009. Estimating survival and migration route probabilities of juvenile Chinook salmon in the Sacramento–San Joaquin River Delta. *North American Journal of Fisheries Management* 30:142-156.

Petts, G. E. 2009. Instream flow science for sustainable river management. *Journal of the American Water Resources Association* (JAWRA) 45(5):1071-1086.

Poff, N. L., J. D. Allan, M. B. Bain, J. R. Karr, K. L. Prestegaard, B. D. Richter, R. E. Sparks, and J. C. Stromberg. 1997. The natural flow regime. *BioScience* 47:769-784.

Postel, S., and B. Richter. 2003. *Rivers for Life: Managing Water for People and Nature*. Island Press, Washington, DC.

PRBO CalPIF (Point Reyes Bird Observatory California Partners in Flight). 2008. *Bringing the Birds Back: A Guide to Habitat Enhancement for Birds in the Sacramento Valley* (R. DiGaudio, K. Kreitinger, and T. Gardali, lead authors). California Partners in Flight Regional Conservation Plan No. 2. http://www.prbo.org/calpif.

Reclamation and USFWS (Bureau of Reclamation and U.S. Fish and Wildlife Service). 2008. Listen to the River: An Independent Review of the CVPIA Fisheries Program. Prepared by a panel of independent reviewers under contract with Circlepoint.

Reynolds, F. L., T. J. Mills, R. Benthin, and A. Low. 1993. Restoring Central Valley streams; a plan for action. Sacramento, California: California Department of Fish and Game. pp. 129. http://www.dfg.ca.gov/fish/documents/Resources/RestoringCentralVallyStreams.pdf.

Sacramento-San Joaquin Delta Conservancy. 2012. *Delta Conservancy Strategic Plan*. Public Review Draft. March 26.

San Francisco Estuary Institute. 2012. Sacramento-San Joaquin Delta Historical Ecology Investigation: Exploring Pattern and Process. Aquatic Science Center. Prepared for the California Department of Fish and Game and Ecosystem Restoration Program. August.

San Joaquin River Group Authority. 2010. *Annual Technical Report on Implementation and Monitoring of the San Joaquin River Agreement and the Vernalis Adaptive Management Plan (VAMP)*. http://www.sjrg.org/technicalreport/2010/2010_SJRGA_Annual_Technical_Report.pdf.

Simenstad, C.A., W. G. Hood, R. M. Thom, D.A. Levy, and D. L. Bottom. 2000. Landscape structure and scale constraints on restoring estuarine wetlands for Pacific Coast juvenile fishes. *Concepts and Controversies in Tidal Marsh Ecology*. M. P. Weinstein and D. A. Kreeger, eds. pp. 597–630. Kluwer Academic Publishers: Dordrecht, Netherlands.

Sommer, T., B. Harrell, M. Nobriga, R. Brown, P. Moyle, W. Kimmerer, and L. Schemel. 2001. California's Yolo Bypass: evidence that flood control can be compatible with fisheries, wetlands, wildlife, and agriculture. *Fisheries* 26:6-16.

Sommer, T., R. Baxter, and B. Herbold. 1997. The resilience of splittail in the Sacramento–San Joaquin Estuary. *Transactions of the American Fisheries Society* 126:961–976.

Sommer, T., C. Armor, R. Baxter, R. Breuer, L. Brown, M. Chotkowski, S. Culberson, F. Feyrer, M. Gingras, B. Herbold, W. Kimmerer, A. Mueller-Solger, M. Nobriga, and K. Souza. 2007. The collapse of pelagic fishes in the Upper San Francisco Estuary. *Fisheries* 32:270–277.

SWRCB (State Water Resources Control Board). 2010. *Development of Flow Criteria for the Sacramento–San Joaquin Delta Ecosystem*. California Environmental Protection Agency, Sacramento, California.

Teal, J. M., N. G. Aumen, J. E. Cloern, K. Rodriguez, and J. A. Wiens. 2009. *Ecosystem Restoration Workshop Panel Report*. CALFED Science Program.

Turner, M. G. 1989. Landscape ecology: the effect of pattern on process. *Annual Review of Ecology and Systematics* 20:265–275.

USFWS (U.S. Fish and Wildlife Service). 2008. Formal Endangered Species Act Consultation on the Proposed Coordinated Operations of the Central Valley Project (CVP) and the State Water Project (SWP). http://www.fws.gov/sfbaydelta/documents/SWP-CVP OPs BO 12-15 final signed.pdf.

USGS (United States Geological Survey). 2001. Nonindigenous species information bulletin: Asian clam, *Corbicula fluminea* (Müller, 1774) (*Mollusca: Corbiculidae*). Florida Caribbean Science Center, Gainesville, FL.

Villamanga, A. M., and B. R. Murphy. 2010. Ecological and socio-economic impacts of invasive water hyacinth (*Eichhornia crassipes*): a review. *Freshwater Biology* 55:282-298.

Whipple, A. A. 2011. Abstract: "Habitat Characteristics of Past Delta Landscapes: Knowledge for Improving Future Ecosystem Resilience." California-Nevada Chapter of the American Fisheries Society 2011 Conference Abstracts. http://www.afs-calneva.org/_files/Cal-Neva_AFS_Conf_2011_Abstracts.pdf. Historical and Current Delta Waterways figure provided via personal communication between San Francisco Estuary Institute Aquatic Science Center and Delta Science Program staff.

Whipple, A. A., R. M. Grossinger, J. C. Collins, and D. Rankin. 2010. The Historical Yolo Basin Landscape: What Parts Make the Whole? Bay-Delta Science Conference Abstract. Sacramento, California.

Wiens, J. A. 2002. Riverine landscapes: Taking landscape ecology into the water. *Freshwater Biology* 47: 501–515.

Williams, J. G. 2006. Central Valley salmon: A perspective on Chinook and steelhead in the Central Valley of California. *San Francisco Estuary and Watershed Science* 4(3):1-418. http://escholarship.org/uc/item/21v9x1t7.

Winder, M., and A. D. Jassby. 2011. Synergies between climate anomalies and hydrological modifications facilitate estuarine biotic invasions. *Ecology Letters* 14:749-757.

Wright, S. A., and D. H. Schoellhamer. 2004. Trends in the sediment yield of the Sacramento River, California, 1957-2001. *San Francisco Estuary and Watershed Science* 2(2): 1-15. http://escholarship.org/uc/item/891144f4.

Yoshiyama, R. M., E. R. Gerstung, F. W. Fisher, and P. B. Moyle. 1996. *Historical and Present Distribution of Chinook Salmon in the Central Valley Drainage of California*. Sierra Nevada Ecosystem Project: final report to Congress. In Assessments, commissioned reports, and background information. Center for Water and Wildlife Resources, University of California at Davis. Davis, California. pp. 309–362.

Photo Credits

Chapter divider *(clockwise from top left)***:** Delta Stewardship Council, L.A. Yarbrough, and California Department of Water Resources

Page 126: California Department of Water Resources

CHAPTER 5

Protect and Enhance the Unique Cultural, Recreational, Natural Resource, and Agricultural Values of the California Delta as an Evolving Place

ABOUT THIS CHAPTER

This chapter describes the unique values that distinguish the Sacramento-San Joaquin Delta (Delta) and make it a special region. It also outlines the Delta Stewardship Council's (Council) five core strategies for protecting and enhancing these values:

- Designate the Delta as a special place worthy of national and state attention
- Plan to protect the Delta's lands and communities
- Maintain Delta agriculture as a primary land use, a food source, a key economic sector, and a way of life
- Encourage recreation and tourism that allow visitors to enjoy and appreciate the Delta, and that contribute to its economy
- Sustain a vital Delta economy that includes a mix of agriculture, tourism, recreation, commercial and other industries, and vital components of state and regional infrastructure

The 2 policies and 19 recommendations to carry out these strategies are found at the end of the chapter. Protecting the Delta as a place also depends on the strategies to reduce flood and other risks to the Delta that are described in Chapter 7.

RELEVANT LEGISLATION

The Sacramento-San Joaquin Delta Reform Act of 2009 declared State policy for the resources and values of the Delta (Water Code section 85054):

> *"Coequal goals" means the two goals of providing a more reliable water supply for California and protecting, restoring, and enhancing the Delta ecosystem. The coequal goals shall be achieved in a manner that protects and enhances the unique cultural, recreational, natural resource, and agricultural values of the Delta as an evolving place.*

The Legislature declares the following objectives inherent in the coequal goals for management of the Delta (Water Code section 85020):

> *(a) Manage the Delta's water and environmental resources and the water resources of the state over the long term.*
>
> *(b) Protect and enhance the unique cultural, recreational, and agricultural values of the California Delta as an evolving place.*

Water Code section 85302(h) provides direction on the implementation of measures to promote the coequal goals and inherent objectives:

> *(h) The Delta Plan shall include recommendations regarding state agency management of lands in the Delta.*

The Delta Reform Act states (Water Code section 85022 (d)):

> *(d) The fundamental goals for managing land use in the Delta are to do all of the following:*
>
> > *(1) Protect, maintain, enhance, and, where feasible, restore the overall quality of the Delta environment and its natural and artificial resources.*
> >
> > *(2) Ensure the utilization and conservation of Delta resources, taking into account the social and economic needs of the people of the state.*
> >
> > *(3) Maximize public access to Delta resources and maximize public recreational opportunities in the Delta consistent with sound resources conservation principles and constitutionally protected rights of private property owners.*
> >
> > *(4) Encourage state and local initiatives and cooperation in preparing procedures to implement coordinated planning and development for mutually beneficial uses, including educational uses, in the Delta.*
> >
> > *(5) Develop new or improved aquatic and terrestrial habitat and protect existing habitats to advance the goal of restoring and enhancing the Delta ecosystem.*
> >
> > *(6) Improve water quality to protect human health and the environment consistent with achieving water quality objectives in the Delta.*

Public Resources Code section 29703.5 describes the Delta Protection Commission's role in providing recommendations to the Delta Stewardship Council:

> *(a) The Delta Protection Commission created pursuant to Section 29735 provides an existing forum for Delta residents to engage in decisions regarding actions to recognize and enhance the unique cultural, recreational, and agricultural resources of the Delta. As such, the commission is the appropriate agency to identify and provide recommendations to the Delta Stewardship Council on methods of preserving the Delta as an evolving place as the Delta Stewardship Council develops and implements the Delta Plan.*
>
> *(b) There is a need for the five Delta counties to establish and implement a resources management plan for the Delta and for the Delta Stewardship Council to consider that plan and recommendations of the commission in the adoption of the Delta Plan.*

This page intentionally left blank.

CHAPTER 5

Protect and Enhance the Unique Cultural, Recreational, Natural Resource, and Agricultural Values of the California Delta as an Evolving Place

The Delta Reform Act provides that the coequal goals of providing a more reliable water supply and protecting, enhancing, and restoring the Delta ecosystem shall be achieved in a manner that protects the unique cultural, natural, recreational, resource, and agricultural values of the Delta as an evolving place. Achieving this objective begins with recognizing the values that make the Delta a distinctive and special place:

- The Delta's geography of low-lying islands and tracts, many below the water level and shaped by sloughs, shipping channels, and rivers; tidal influences; levees; and other water controls is unique among California landscapes.
- The Delta retains a rural heritage, characterized by farms and small towns linked by navigable waterways and winding country roads.
- The Delta's agricultural economy is vital to the region and contributes to California's important agricultural economy.
- The Delta is a region where maritime ports, commercial agriculture, and expanding cities coexist with a unique native ecosystem that is home to many species of wildlife and fish.
- The Delta is a place of multicultural tradition, legacy communities, and family farms.
- The Delta provides opportunities for recreation and tourism because of its unique geography, mix of activities, and rich natural resources.

The Delta's uniqueness, however, does not exempt it from change. Increasing pressures of growing populations, shifting commodity markets, climate changes, and rising sea level will require new ways of adaptation for this region. Some changes are driven by the Delta's location at the center of California's water systems and are required to meet statewide goals of restoring the Delta's ecosystem and improving water supply reliability. Other changes may be caused by floods, earthquakes, or other events that threaten the Delta's levees and islands. Some changes can be managed by policies that shape how the Delta's traditions are honored and its history preserved; guide new development; enhance recreation and tourism; and encourage agriculture, business expansion, and economic development.

Protecting the Delta as an evolving place means accepting that change will not stop, but that the fundamental characteristics and values that contribute to the Delta's special qualities and that distinguish it from other places can be preserved and enhanced while accommodating these changes (Delta Vision Blue Ribbon Task Force 2008). It does not mean that the Delta should be a fortress, a preserve, or a museum.

The Council envisions a future where the Delta's unique qualities are recognized and honored. Agriculture will continue to thrive on the Delta's rural lands; and its cities, ports, and rural villages will be desirable places to live, work, and do business. Visitors to the region will enjoy recreation on and in its waterways, marshes, resorts, parks, and historic legacy communities. The Delta's land uses and development will be resilient, protecting the rural character of the area, reducing risks to people and property, adjusting to changing conditions, and promoting the ability to recover readily from distress. The Delta's economic vitality will provide resources to respond to change and to support the families and businesses that make the Delta home. The vision of the Delta as an evolving place also acknowledges the role of Delta residents in shaping the future of the region through active and effective participation in Delta planning and management.

Creating a Common Vision of the Delta as a Place

The Delta Reform Act recognizes not only the uniqueness of the region, but also that it is managed and influenced by many State of California (State), federal, and local agencies, often with differing views about the Delta and with overlapping and sometimes conflicting jurisdictions. Through the Delta Plan, the Council intends to foster a common vision for the future of the Delta as a place and to promote more effective coordination among these agencies. (See sidebar, Looking at the Delta.)

Fashioning this common vision has begun by drawing much of the information and many of the strategies of this chapter from these agencies' reports and recommendations, including the following documents:

- The *Proposal to Protect, Enhance, and Sustain the Unique Cultural, Historical, Recreational, Agricultural, and Economic Values of the Sacramento-San Joaquin Delta as an Evolving Place* developed by the Delta Protection Commission (DPC) (DPC 2012a)
- The DPC's *Economic Sustainability Plan for the Sacramento-San Joaquin Delta* (ESP) (DPC 2012b)
- The *Recreation Proposal for the Sacramento-San Joaquin Delta and Suisun Marsh* (Recreation Proposal) developed by California State Parks (California State Parks 2011)
- The Sacramento-San Joaquin Delta Conservancy's (Delta Conservancy) *Strategic Plan*

The Public Resources Code (section 29703.5(a)) names the DPC as "the appropriate agency to identify and provide recommendations to the Council on methods of preserving the Delta as an evolving place." The DPC is an agency created in 1992 by the Delta Protection Act to plan for and guide natural resource conservation and enhancement in the legal Delta while sustaining agriculture and meeting increased recreational demand.

LOOKING AT THE DELTA

The Delta presents itself from three vantages that display alternative aspects of its character.

From the water, the Delta is a thicket of sloughs, rock-lined channels, and open waterways where the land lies unseen behind tall levees and riparian vegetation. This is a Delta of recreational boating and oceangoing freighters, piers and lift bridges, diversions and water control structures, fish and diving ducks, resorts and marinas.

Another view of the Delta is a predominantly rural, agricultural landscape dotted with historic villages and where waterways are hidden on the other side of the levee, to be glimpsed only from bridges and levee-top roads. This is a Delta of vineyards, orchards, farm fields, ditches, and waterfowl hunting clubs; of historic farmsteads and one-of-a-kind shops and restaurants; and of farm machinery and bicyclists.

A third view of the Delta looks out from its metropolitan areas: Stockton, Manteca, Lathrop, Tracy, Contra Costa County's shoreline suburbs, Suisun City, Fairfield, Sacramento, and West Sacramento. This is a Delta of downtowns, neighborhoods, and new suburbs; cooling summer breezes and clammy winter fog; waterfront parks and a catch of striped bass in the freezer; and ports, warehouses, offices, and other job sites.

DP-188

As provided in Water Code section 85301, the DPC developed the *Proposal to Protect, Enhance, and Sustain the Unique Cultural, Historical, Recreational, Agricultural, and Economic Values of the Sacramento-San Joaquin Delta as an Evolving Place* (DPC 2012a). This proposal was submitted to the Council for incorporation into the Delta Plan. The proposal includes a plan to recognize the Delta as a place of special significance by applying for a federal designation of the Delta as a National Heritage Area (NHA). The NHA designation is granted by the U.S. Congress to places where natural, cultural, historic, and recreational resources combine to form a distinctive landscape and tell a nationally important story about the country and its experience.

The DPC also recommends strategies to support increased investment in agriculture, recreation, tourism, and other resilient land uses in the Delta. These strategies are derived from the ESP (DPC 2012b). Established in 2009, the Delta Conservancy is responsible for implementing ecosystem restoration projects protecting and preserving agriculture and working landscapes; increasing recreation and tourism opportunities; promoting legacy communities and economic vitality; and protecting, conserving, and restoring the region's physical, agricultural, cultural, historical, and living resources (Public Resources Code section 32322). Careful coordination between the DPC and Delta Conservancy can maximize the impact of both agencies' economic development activities.

Protecting the Delta as an Evolving Place Is Inherent in the Coequal Goals

Protecting the Delta as an evolving place is inherent in the coequal goals of providing a more reliable water supply for California and protecting, restoring, and enhancing the Delta ecosystem. This is partly because attaining these two goals will necessitate a growing awareness among Californians of the Delta and its values, including its agriculture, recreation, natural resources, and unique culture. It is also because Delta residents benefit from the levees that help convey fresh water through the Delta; enjoy the wildlife, fish, and recreation that the Delta ecosystem produces; and work for its water management agencies and facilities. Changes required to provide a more reliable water supply or restore the ecosystem will influence the kind of place the Delta becomes, especially if structures to improve conveyance or areas of restored habitat significantly alter the Delta's familiar farming landscape. At the same time, the needs to protect the Delta's land uses and people will shape and constrain decisions about water supplies and ecosystem restoration, including allocation of water supplies, flow and salinity objectives, levee priorities, and how impacts to communities and land uses are mitigated.

Water for agricultural, municipal, and industrial uses is a key to the Delta as a place. Delta communities are the most dependent of all Californians on Delta water supplies, which support its residents, businesses, and farms. They, like other Californians, can often do more to use water more efficiently and to develop alternative supplies through recycling, conjunctive use of groundwater, or participation in regional water supply projects. Because the communities and economy of the Delta require water of reliable quality as well as amount, updates to the Bay-Delta Water Quality Control Plan have special influence on the region. The Delta is also influenced by other Central Valley water quality plans because they protect the quality of water for Delta consumers, farmers, and recreationists and the costs Delta residents and businesses pay to meet clean water standards.

A healthy ecosystem is also important to the Delta's communities. Residents find joy and relaxation in outdoor recreation and the connection with nature that the Delta ecosystem provides. Visitors drawn to its scenery, waterways, fish, and wildlife support tourism businesses. Protecting the ecosystem maintains these benefits and restoring it can expand them, especially when it can be accomplished in ways that enhance the Delta's working landscape. Coordinating restoration with planning for flood control can help control costs for levee improvement and management, draw on multiple sources of funds for multipurpose flood control investments, and provide alternate uses for areas that cannot be protected cost effectively. Restoring marshes, riverbanks, and riparian areas will alter how some land is used, but the impacts of these changes on the Delta's unique values can be managed through cooperation, careful design to lessen or avoid adverse effects, or reasonable mitigation of unavoidable impacts.

The Delta as a Place

The California Delta is a unique place distinguished by its geography, legacy communities, a rural and agricultural setting, vibrant natural resources, and a mix of economic activities. This section describes the features that make the Delta unique. Its 839,640 acres of land, sometimes centered on a wide river but laced with a network of narrow channels and sloughs, stretch to the horizon, bounded only by the levees that were built to drain the Delta's marshes and floodprone riversides. The Legislature has found that the Delta's uniqueness is particularly characterized by its hundreds of miles of meandering waterways and the many islands adjacent to them, and has described the Delta's highly productive agriculture, recreational assets, fisheries, and wildlife as invaluable resources (Water Code section 12981(b)). These natural assets, including the ecosystem and water resources as described in Chapters 3, 4, and 6, are among the Delta's important values.

The Delta is composed of three areas recognized in California law. The Primary Zone is the largest and includes 490,050 acres at the heart of the Delta (Public Resources Code section 29728). It is primarily rural farmland, but also includes several small towns established in the nineteenth and twentieth centuries. The Secondary Zone includes 247,320 acres surrounding the Primary Zone (Public Resources Code section 29731). It also includes farmland, but is increasingly dominated by the region's cities and suburbs. Suisun Marsh lies northwest of the Primary Zone, encompassing 106,570 acres (Public Resources Code section 29101) primarily of managed wetland. The Suisun Marsh overlaps the boundary of the Delta by about 4,300 acres (see Figure 5-1).

The Legislature has declared that the Delta is a natural resource of statewide, national, and international significance, and that the cities, towns, and settlements within the Delta are of significant historical, cultural, and economic value (Public Resources Code sections 29701 and 29708). However, not all Delta users, visitors, or residents recognize or appreciate the Delta's values. In a recent survey, 78 percent of Californians said they had not heard of or did not know about the Delta (Probolsky Research 2012). A survey in 2007 found that nearly half of Stockton residents had only a vague idea—or none at all—that they lived in or near the Delta (*Stockton Record* 2012).

This lack of a clearly recognized, widely communicated identity for the Delta is described as the lack of a "brand." Delivering a coordinated message about the Delta and its resources is difficult because responsibilities for the Delta are divided among so many agencies. Many visitors and even some residents of Delta cities and suburbs are unfamiliar with the region beyond their travel route or community, or know it only in name from news media reports about conflicts over its water and natural resources. To some, the Delta's flat agricultural landscape is dull and monotonous, and its resources are "out of sight and out of mind." Access into the Delta by first-time visitors can be difficult because of its winding roads and lack of amenities that signify a special region; simplify wayfinding; educate travelers about an area's history, culture, and natural resources; or encourage public access and recreation.

Delta Primary and Secondary Zones and Suisun Marsh

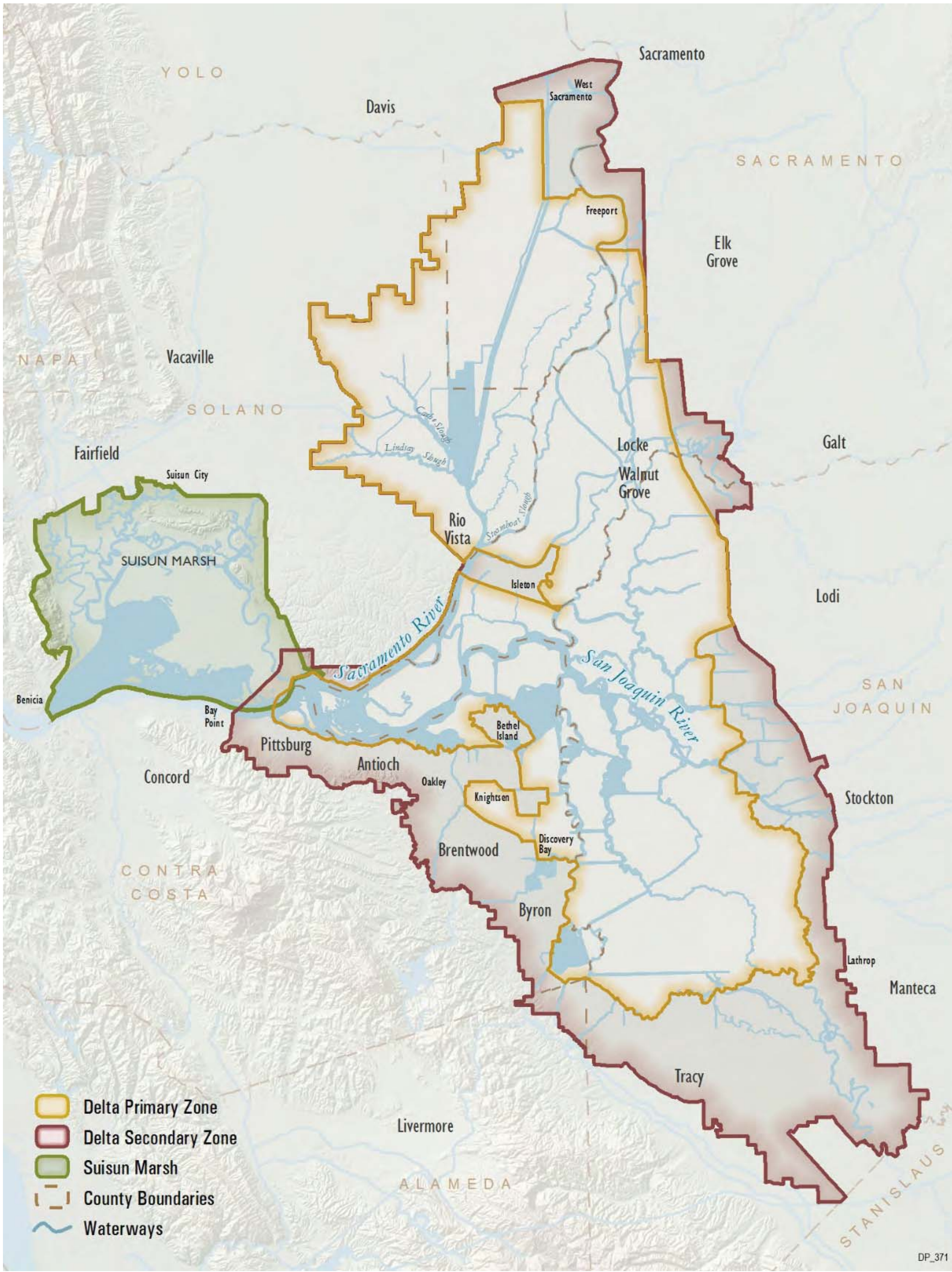


Figure 5-1

The Delta's People

About 570,000 people reside in the Delta, according to the 2010 Census. Ninety-eight percent of them live in the Delta's Secondary Zone, with the remainder in the Primary Zone. Prior to the recent recession, the population of the Delta's Secondary Zone had been growing rapidly, increasing almost 56 percent since the 1990 Census, a rate twice as fast as the state as a whole. Much of that increase occurred in new communities in previously unincorporated county areas, such as Discovery Bay; rapidly growing towns and communities such as Brentwood and Oakley on State Route 4; and cities such as Sacramento, West Sacramento, Stockton, and Lathrop. The age and household composition of the Delta's population is similar to California as a whole, but with slightly younger and larger families. About half the Delta's population is between the ages of 21 and 54, and about 29 percent are younger than 18 years old (DPC 2012b).

In contrast, the population of the Primary Zone has been essentially unchanged over those 20 years. The Primary Zone is also composed primarily of older people without children, living in smaller households.

Today, most Delta residents describe themselves as white or Hispanic, with the next largest groups being Asian, other races, and African-American or black. About one-third describe themselves as Hispanic. This diverse population reflects the many United States regions and foreign lands from which settlers emigrated to the Delta, including Mexico, China, Japan, Portugal, the Philippines, and other countries. These origins are reflected in communities and neighborhoods like Locke, an early twentieth century town built primarily by Chinese farmworkers. Cultural events honor many ethnic traditions in the Delta, including Chinese and Cambodian New Years, Portuguese festas, Greek holidays, Indian Diwali celebrations, Filipino fiestas, Cinco de Mayo events, and Juneteenth commemorations. Other festivals feature Delta agriculture, such as the Courtland Pear Fair and the Stockton Asparagus Festival (California State Parks 2011).

The Delta's Communities

The region's urban communities include the cities of Sacramento, West Sacramento, Stockton, Lathrop, Manteca, Tracy, Oakley, Brentwood, Antioch, Pittsburg, Benicia, Fairfield, Suisun City, Rio Vista, and Isleton, and the unincorporated communities of Freeport, Mountain House, Byron, Discovery Bay, Bethel Island, and Knightsen. They are located entirely or partially in the Delta's Secondary Zone or in the secondary management area of Suisun Marsh. Unincorporated communities in the Primary Zone include Clarksburg, Courtland, Hood, Locke, Walnut Grove, and Ryde. Appendix B includes maps of these unincorporated communities.

The general plans of Delta cities and counties describe where development of these communities may occur. These plans or actions by the local area formation commissions describe "spheres of influence" (SOIs) for each jurisdiction and often identify an urban limit line beyond which intense development cannot occur without amendment of the plan. About 26,000 acres of the Delta within these SOIs are expected to undergo urbanization (DPC 2012b) (see Figure 5-2). To encourage the location of new development within these SOIs rather than in rural areas, Chapter 7 policies exempt development in these areas from policies to increase flood protection standards. The Delta Plan includes no policies or recommendations to control land use or density in these communities.

Among the Delta's unincorporated communities, Bethel Island warrants a special note because of its flood risks, the development planned there, and its lack of public services. Its developed area occupies part of the 3,500-acre island, most of which is planned for rural agricultural or visitor-serving commercial uses. About 2,100 people reside on the island in about 1,300 residences concentrated on the island's south central shoreline, four mobile home parks, or 13 commercial marinas. Approximately 15 miles of levees surround the island, which is below sea level, limiting the drainage of floodwaters in the event of a levee breach.

A single road, Bethel Island Road, links the island to the mainland at the city of Oakley, complicating emergency response or evacuation in the event of flooding. Although the entire island is included in the urban limit line that Contra County's voters approved in 2006, development on the island clusters around Delta Coves, a 495-unit water-oriented residential development that was permitted in 1973, but that still remains unfinished, in part because of the bankruptcy of its developer. Other development includes mobile home parks and retail areas. Rural uses include single-family homes along the island's shoreline, marinas, resorts, a golf course, rural residential uses, and farmland. Contra Costa County's General Plan seeks to preserve and enhance the rural quality of Bethel Island and still allow for planned residential and commercial growth related to water-oriented recreation. The general plan notes that development other than a single home on existing parcels must await resolution of several issues, including improvement of the community's public services, levees, and emergency evacuation routes. Because of its flood risks and its rural character, Bethel Island is not excluded from the Delta Plan policy limiting new urban development. Restrictions on development on Bethel Island are consistent with the Contra Costa County General Plan.

As described in Chapter 2, covered actions subject to the Delta Reform Act do not include plans, programs, or projects within the Delta's Secondary Zone that a metropolitan planning agency has determined are consistent with a sustainable communities strategy adopted under California planning law. These sustainable communities strategies will, in part, accomplish the following:

- Identify the general location of uses, residential densities, and building intensities within the region.
- Identify areas within the region over their 20-plus-year planning period sufficient to house the population of the region.
- Identify areas within the region sufficient to house an 8-year projection of the regional housing need for the region.
- Identify a transportation network to serve the transportation needs of the region.
- Gather and consider information regarding resource areas and farmland in the region.
- Set forth a forecast development pattern, which, when integrated with the transportation network and other transportation measures and policies, will reduce greenhouse gas emissions from automobiles and light trucks. The sustainable community strategy development pattern will need to be based upon "current planning assumptions" that include the information in local general plans and SOI boundaries.

As provided in Water Code section 85212, the Council will cooperate with local and regional planning agencies to provide timely advice about sustainable community strategies and other local and regional plans for consistency with the Delta Plan. This will include reviewing their consistency with the ecosystem restoration needs of the Delta and whether these plans set aside sufficient lands for natural resource protection to meet the Delta's ecosystem needs. Through this coordination, decisions about locating and planning new urban development in the Secondary Zone can be coordinated to meet local communities' housing and other needs, as Water Code section 85022(d)(4) provides, while protecting and enhancing the Delta as an evolving place.

Delta Communities

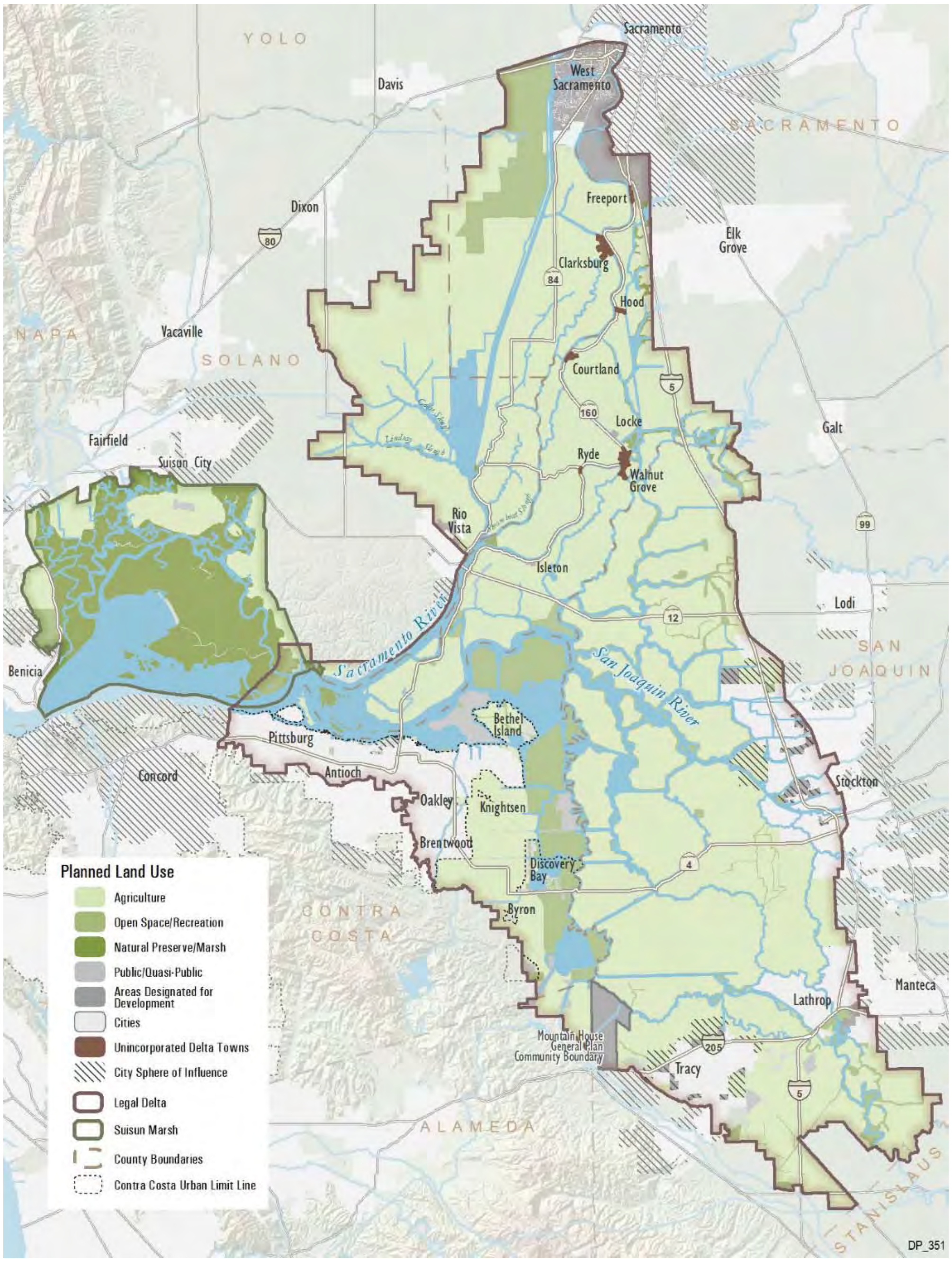


Figure 5-2 The map shows land uses designated by city and county general plans. Within cities' SOIs, the map shows land use designations proposed in city general plans, where available. In cases where cities have not proposed land uses within their SOIs, the map shows land uses designated by county general plans.

Sources: City of Benicia 2003, Contra Costa County 2008, Contra Costa County 2010, City of Fairfield 2008, City of Lathrop 2012, City of Manteca 2012, Mountain House Community Services District 2008, City of Rio Vista 2001, SACOG 2009, City of Sacramento 2008, Sacramento County 2011, Sacramento County 2012, Sacramento County 2013, San Joaquin County 2008a, San Joaquin County 2008b, Solano County 2008a, Solano County 2008b, City of Stockton 2011a, City of Stockton 2011b, City of Suisun City 2011, City of Tracy 2011a, City of Tracy 2011b, City of West Sacramento 2010, Yolo County 2010a, Yolo County 2010b.

The Delta's Legacy Communities

Bethel Island, Clarksburg, Courtland, Freeport, Hood, Isleton, Knightsen, Rio Vista, Ryde, Locke, and Walnut Grove are the Delta's legacy communities (Public Resources Code section 32301(f)). They are the residential, commercial, processing, and retail centers of the Delta, and resonate with its history and culture. Each community has its own character. Bethel Island is a recreation destination. Clarksburg and Courtland are centers for wine and pear production. Freeport and Hood were transportation centers, with river landings and rail spurs to move goods. Locke and Walnut Grove had large Asian populations who worked at packing sheds and surrounding local farms. Ryde is known for its landmark hotel, and Isleton is known for festivals and visitor-serving businesses. Rio Vista is the largest community, and Knightsen is a small community known for several nearby horse ranches. All legacy communities except Freeport, Isleton, and Bethel Island are in the Primary Zone. Rio Vista is partly in the Primary Zone and partly outside the Delta. The DPC ESP highlights the rich cultural histories of these distinctive communities and notes the importance of enhancing their legacy themes and creating better awareness of them. It highlights planning to strengthen these communities by building on the agricultural uses that surround them. It also recommends enhancing the Delta's recreation and tourism opportunities by improving these towns' lodging, entertainment, and retail options; encouraging agritourism; restoring historic buildings; and promoting context-sensitive infill development, including housing for the Delta's workforce.

Flood risks in these communities are higher than in the Delta's cities, as noted in Chapter 7, and they are too small to be capable of financing major levee improvements without significant assistance. According to the ESP, opportunities for residential or visitor-serving recreation developments in these communities may be impaired if flood risks are too high or development regulations are unpredictable or too burdensome. Although improvements to these communities' historic structures are exempt from Federal Emergency Management Agency (FEMA) floodproofing standards (FEMA 2008), flood risks, floodproofing standards for new development, and flood insurance costs can be barriers to business investment or development.

THE LEGACY OF THE DELTA'S NATIVE CALIFORNIA INDIANS

People have occupied the Delta for thousands of years. Early people gathered wild plants, including seeds, roots, greens, mushrooms, and nuts; hunted for rabbits, waterfowl, tule elk, or antelope; and speared or netted salmon, sturgeon, and other fish. Acorn processing allowed populations to grow. Permanent villages of 100 or more residents were established on sand mounds along major waterways, at the margins of tule marshes, and on the shores of Suisun Bay. Sandy uplands on Delta islands held smaller settlements. Boats of tule reeds were used to travel Delta waterways. Trade with neighbors brought obsidian and other tool stones, shell or bone ornaments, charm stones, and other goods from the coast and Sierra.

Four main groups resided in the Delta: Nisenan on the north, Miwok on the east, Yokuts in the south Delta and Contra Costa shoreline, and Patwin around Suisun Marsh and Putah Creek. Their presence is still acknowledged in place names (for example, Yolo, Suisun, and Mokelumne) and in artifacts such as stone pestles and bedrock mortars for grinding seeds and nuts; twined basketry of rushes and other plants; ancient habitations demarked by charcoal, shells, or other refuse; and cemeteries where loved ones were carefully buried, sometimes with ochre, beads, and other objects, or cremated. Today their descendants sustain a contemporary native California Indian community in the Delta.

Sources: Beals 1933, Bennyhoff and Fredrickson 1969, Fredrickson 1974, Johnson 1978, Kroeber 1925, Kroeber 1932, Levy 1978, Moratto 1984, University of California Archaeological Survey 1956, Wallace 1978, Wilson and Towne 1978

DP-189

Climate Change

Historical, cultural, and economic resources of the Delta are subject to the impacts of climate change. An increase in sea level of up to 55 inches is projected to occur by 2100. Along with increased flood risk associated with rising sea levels and changes in runoff timing and intensity, levees, highways, and other infrastructure that support the Delta's communities and economy will be threatened. In addition, land use planning is complicated by the prospect of rising sea levels and increased flooding that may accompany climate change. Rising water levels and more severe flooding will increase hazards to land uses and developments, and confound efforts to identify safe locations for new homes and businesses.

Impacts on agriculture, such as decreasing revenues, are also likely if Delta water supplies increase in salinity (Lund et al. 2007) and water demand increases. Impacts on agriculture from warming temperatures could reduce yields and increase vulnerability to weeds and pests (California Resources Agency 2008), as well as increase soil subsidence rates through increased rates of organic matter oxidation. In addition, Delta recreation and tourism could be affected by changes in Delta fisheries.

Land Use Planning in the Delta and Suisun Marsh

The land uses in the Delta are the result of myriad decisions made by residents, businesses, investors, and others since its settlement. These decisions are shaped today by local and State agencies that are responsible for planning or regulating land use or development. Primary authority for land use planning rests with the Delta's twelve cities and five counties, which are required to adopt comprehensive long-range general plans to guide development. In addition, the Legislature has authorized three State agencies to oversee land use planning by local governments or directly regulate land use actions in the Delta and the Suisun Marsh: the Council, the DPC, and the San Francisco Bay Conservation and Development Commission (BCDC). The Council and the DPC have concurrent jurisdiction in the Delta's Primary Zone, while the Council and BCDC have concurrent jurisdiction in the Suisun Marsh. The DPC and BCDC must ensure that local land use planning is consistent with their own laws and plans, and must also certify that any covered actions that they carry out or approve, such as updating their plans, are consistent with the Delta Plan (see Table 5-1).

The Council's Role

The Legislature has declared that existing developed uses and future developments that are carefully planned and developed consistent with Delta Reform Act policies are essential to Californians' economic and social well-being, especially those who live or work in the Delta. The Delta Reform Act includes six goals for managing land use (Water Code section 85022(d)):

(1) *Protect, maintain, enhance, and, where feasible, restore the overall quality of the Delta environment and its natural and artificial resources.*

(2) *Ensure the utilization and conservation of Delta resources, taking into account the social and economic needs of the people of the state.*

State Agencies with Land Use Jurisdiction in the Delta

TABLE 5-1

State Agency	Law	Plan
Delta Stewardship Council	Sacramento-San Joaquin Delta Reform Act of 2009	Delta Plan
Delta Protection Council	Delta Protection Act of 1992	Delta Land Use and Resource Management Plan for the Primary Zone of the Delta
San Francisco Bay Conservation and Development Commission	McAteer-Petris Act of 1965, Suisun Marsh Preservation Act of 1977	San Francisco Bay Plan, Suisun Marsh Protection Plan

> *(3) Maximize public access to Delta resources and maximize public recreational opportunities in the Delta consistent with sound resources conservation principles and constitutionally protected rights of private property owners.*
>
> *(4) Encourage state and local initiatives and cooperation in preparing procedures to implement coordinated planning and development for mutually beneficial uses, including educational uses, in the Delta.*
>
> *(5) Develop new or improved aquatic and terrestrial habitat and protect existing habitats to advance the goal of restoring and enhancing the Delta ecosystem.*
>
> *(6) Improve water quality to protect human health and the environment consistent with achieving water quality objectives in the Delta.*

Goals 2, 3, and 4 are addressed in this chapter.

In addition, Water Code section 85305(a) provides, in part:

> *The Delta Plan shall attempt to reduce risks to people, property, and state interests in the Delta by promoting…appropriate land uses.*

Water Code section 85022(a) directs "state and local land use actions identified as covered actions pursuant to section 85057.5 be consistent with the Delta Plan" and that the section's "findings, policies, and goals apply to Delta land use planning and development." Thus, the Council's role in reviewing land use actions is to consider the full range of State interests in the Delta, including the economic and social well-being of Californians, environmental protection, use and conservation of resources, public access and recreation, habitat restoration and enhancement, water quality, and flood protection.

The DPC's Role

The DPC *Land Use and Resource Management Plan for the Primary Zone of the Delta* (2010) guides land uses in the Primary Zone. Local government general plans must be consistent with the DPC's land use and resource management plan. Local government land use actions may be appealed to the DPC for review of consistency with the land use and resource management plan. Chapter 2 describes the special role that the Delta Reform Act gives to the DPC to review and comment on significant projects or programs, such as ecosystem restoration or flood control projects, under consideration by the Council. The referral of projects to DPC for its review and comment and the membership of the DPC chair on the Council assure that the Delta communities will have a voice concerning actions' effects on existing and planned uses of the Delta.

The DPC's management plan states these goals for land use in the Primary Zone (DPC 2010):

> *Protect the unique character and qualities of the Primary Zone by preserving the cultural heritage, strong agricultural/economic base, unique recreational resources, and biological diversity of the Primary Zone. Direct new non-agriculturally oriented non-farmworker residential development within the existing unincorporated towns (Walnut Grove, Clarksburg, Courtland, Hood, Locke, and Ryde).*
>
> *Encourage a critical mass of farms, agriculturally-related businesses and supporting infrastructure to ensure the economic vitality of agriculture within the Delta.*

DPC's management plan also acknowledges the importance of balancing urban development with the protection of agriculture and other rural lands (DPC 2010):

> *The periphery of the Delta is undergoing rapid urbanization associated with substantial population growth. Current and future population growth increases the demand for developable land, particularly in areas near the Bay area, Stockton, and Sacramento. This demand results in the conversion of open space, primarily agricultural land, to residential and commercial uses. Increasing concern exists regarding the potential for urbanization and projects in the Secondary Zone to impact the Primary Zone.*

Thus, the DPC's role in land use review is primarily to protect agricultural land, recreational uses, and biological diversity in the Delta's Primary Zone from urban development, direct most residential development within existing towns, and ensure the economic vitality of Delta agriculture.

BCDC's Role

The BCDC was established by the McAteer-Petris Act in 1965. The agency prepared the *San Francisco Bay Plan* to guide the conservation of the Bay's natural resources and development of its shoreline. In 1977, BCDC's authority was expanded to protect wildlife use and retain biological diversity of the Suisun Marsh under the Suisun Marsh Preservation Act. With respect to land use, the Suisun Marsh Preservation Act (Public Resources Code section 29003(e) and (f)) calls for:

- Development and implementation of plans and policies to protect the marsh from degradation by excessive human use
- Definition and establishment of a buffer area consisting of upland areas that have high wildlife values themselves and also contribute to the integrity and continued wildlife use of the wetlands within the marsh

BCDC's *Suisun Marsh Protection Plan* (SMPP) guides land use and development in the Marsh (BCDC 1976). The SMPP designates an 89,000-acre primary management area of waterways, including Suisun, Honker, and Grizzly bays, tidal marshes, and managed wetlands; and a buffer zone of upland grasslands and agricultural land composing a 22,500-acre secondary management area. Both the Bay Plan and the SMPP apply to Suisun Marsh, and the SMPP controls if there is a conflict. BCDC also is the federally designated State coastal management agency for the San Francisco Bay segment of the California coastal zone. The federal Coastal Zone Management Act (CZMA) empowers BCDC to ensure that federal projects and activities are consistent with BCDC's laws and policies. A marsh development permit from BCDC is required to place fill, dredge, construct a structure, substantially change land use, subdivide property, or grade land in the wetlands and waterways of the Suisun Marsh.

BCDC retains planning and permitting authority in the primary management area of the Marsh, but shares authority in the secondary management area with local government agencies and special districts. The Suisun Marsh Preservation Act authorizes BCDC to delegate authority to issue marsh development permits to local agencies and special districts with jurisdiction in the marsh after BCDC has certified that their components of the Suisun Marsh Local Protection Program (LPP) are consistent with the Suisun Marsh Preservation Act and the SMPP. BCDC first certified all the components of the LPP in the early 1980s. LPP components can be amended only after BCDC holds a public hearing and votes for recertification. Permits granted by local governments for projects in the secondary management area under the authority of their LPP component may be appealed to BCDC.

Thus, BCDC's role in the Suisun Marsh is to protect the unique natural resources of the Suisun Marsh from the potential adverse effects of development by directly regulating land use in the primary management area of the marsh and working with local government to regulate land use in the secondary management area.

Other Agency Jurisdictions

Land use and development in the Delta are also affected by other State and federal agencies. The State Lands Commission has jurisdiction over hundreds of miles of waterways in the Delta, and issues leases for in-stream structures and uses. The Central Valley Flood Protection Board issues permits to encroach in floodways and State flood management facilities. The State and regional water quality control boards control discharges from development to public waters. The California Department of Fish and Wildlife (DFW) regulates projects that affect waterways or habitats of State-listed endangered or rare species.

Among federal agencies, FEMA has a significant effect in the region by establishing floodproofing standards for new development in communities that participate in its National Flood Insurance Program. The U.S. Army Corps of Engineers oversees the filling of public waters and wetlands. The U.S. Fish and Wildlife Service and the National Marine Fisheries Service regulate development that affects essential fish habitat or federally listed endangered or rare species. Some Delta landowners see these complex rules as a barrier to the development and use of private land. As described in Chapter 2, the Delta Plan Interagency Implementation Committee will improve coordination among regulatory agencies to ease some of these barriers.

Minimizing Land Use Conflicts

Poorly sited or designed development can also encourage additional people to place their lives and property at risk as well as restrict ecosystem restoration opportunities (see Chapter 4 and Chapter 7). Many uses are already in hazardous locations. For example, about 116,000 residential structures are located in the 100-year floodplain of the Delta, mostly near Sacramento, West Sacramento, and Stockton. Almost 8,000 residences are below mean higher high water (DWR 2008). Land use planning is complicated by the prospect of rising sea levels and increased flooding that may accompany climate changes. Some necessary water facilities, ecosystem restoration projects, or flood management facilities may need to be located on farmlands or in other locations that are inconsistent with local land use plans. State and federal agency projects are not required to secure approvals from local governments or the DPC, but nevertheless should avoid conflicts with existing and planned land uses when feasible. These projects can alter scenic views, make noise, create conflicts with adjoining land uses, generate traffic, or disrupt transportation routes if not planned carefully. Fully considering local resident views and local government positions can minimize misunderstandings, reduce avoidable conflicts, and build trust and cooperation.

The Delta's Economy

This section provides an overview of the primary sectors that make up the Delta economy. The Delta's economy is primarily urban and service oriented. The Delta is a diverse, growing, and economically integrated region that in many respects is outperforming the state as a whole. Transportation, warehousing, and utilities are important sectors. Construction, housing, and real estate are also important, but have declined with the recent recession. Retail, education, health care, and accommodations are the top employment sectors. The Primary Zone is less diverse, and depends on agriculture and, to a lesser extent, recreation and tourism. Stockton, Sacramento, and other nearby urban areas provide employment for professionals who commute from the Primary Zone, and less-skilled workers commute into the Primary Zone to jobs in agriculture and food processing.

Agriculture and the Delta's Economy

The total value of Delta crops was approximately $702 million in 2009. Truck and vineyard crops account for 54 percent of crop revenues on 18 percent of acreage. The top five Delta crops in terms of value were (1) processing tomatoes, (2) wine grapes, (3) corn, (4) alfalfa, and

(5) asparagus. The highest per-acre values in the Delta come from truck crops mainly situated in the southern Delta and deciduous crops principally located in the northern Delta. Table 5-2 summarizes top crops by gross value and acreage.

Top Five Crops in the Delta

TABLE 5-2

Position (2009)	By Gross Value	By Acres Grown
1	Tomatoes	Corn
2	Wine Grapes	Alfalfa
3	Corn	Tomatoes
4	Alfalfa	Wheat
5	Asparagus	Wine Grapes

Source: DPC 2012b

When related value-added manufacturing such as wineries, canneries, and dairy products are included, the total economic impact of Delta agriculture is 13,179 jobs, $1.059 billion in value added, and nearly $2.647 billion in economic output in the five Delta counties. Including value-added manufacturing, the statewide impact of Delta agriculture is 25,125 jobs, $2.135 billion in value added, and $5.372 billion in economic output (DPC 2012b).

See the Agriculture in the Delta section for a more detailed description of agriculture and its contribution to the Delta's way of life and economy.

The Delta's Recreation and Tourism Economy

Recreation and tourism are important contributors to the Delta's economy. DPC's ESP estimates that Delta recreation and tourism support 3,000 jobs with $100 million in wages in the Delta counties; $312 million in direct expenditures in the Delta by anglers, hunters, boaters, picnickers, campers, hikers, bicyclists, visitors driving for pleasure, and others who recreate in parks, wildlife areas, trails, or roadways; and a total of $175 million in value added to the regional economy. Statewide, Delta recreation and tourism support 5,200 jobs and contribute $348 million in value added.

Despite these significant contributions, the Delta's recreation and tourism economy has been relatively flat since the 1990s. The recreation and tourism sectors suffer from limited recognition and understanding of the Delta, and the lack of an overall marketing strategy for the region. Brannan Island State Recreation Area, the best improved State park, is scheduled to close due to budget constraints. Many other public lands lack facilities for visitors. Motor boat registrations have declined in the region. Participation in fishing and hunting has declined also. Private-sector recreation and tourism businesses are stagnant, with employment unchanged over 2 decades and little investment in new facilities. Inadequate levees leave key visitor attractions, including the legacy communities, at risk, as described in Chapter 7. Flood risks, flood insurance, and difficulties in designing attractive but floodproof visitor facilities hinder new investment in recreation and tourism businesses.

Other Contributors to the Delta Economy

The Delta's infrastructure not only supports its residents and businesses, but also includes facilities that transport people and products through the Delta from the Sierra on the east to the Bay Area on the west, or from the Sacramento Valley on the north to the San Joaquin Valley on the south. The Delta's economy benefits from the surface transportation, utilities, and other infrastructure that crisscross the Delta to serve local needs, provide access to regional urban markets, and, in turn, link the Delta's economy to national and global markets.

The Delta's most recognizable infrastructure components are its levees, which are described in Chapter 7. Key transportation corridors include Interstates 80, 5, and 205; State Routes 4, 12, and 160; and railroads operated by Union Pacific, Burlington Northern Santa Fe, Amtrak, and the Altamont Commuter Express. County roads are important for transporting crops to market and for local circulation.

The ports at Stockton and West Sacramento are served by deep water shipping channels that the U.S. Army Corps of Engineers maintains along the San Joaquin and Sacramento rivers, and the Sacramento Deep Water Ship Channel. These ports connect to San Francisco Bay and ultimately to the Pacific Ocean, providing a valuable asset to Delta communities. Rice and other crops grown in the Central Valley and other products are exported across their docks, and fertilizer and other bulk commodities are imported. The Maritime Highway Corridor is a recent initiative to expand maritime traffic between the Delta ports and the Port of Oakland, in part to reduce truck travel and its air quality impacts. Areas for water-dependent industries are located in Collinsville, Rio Vista, Pittsburg, and Antioch, where they benefit from the Delta's abundant and high-quality water.

Other infrastructure in the Delta includes water, drainage, and wastewater treatment facilities. Stockton and Sacramento draw drinking water at least partly from the Delta and discharge wastewater there. The Delta is the site of forebays, pumps, and water control structures of the Central Valley Project and State Water Project, as described in Chapter 3. Aqueducts and other facilities serving the East Bay Municipal Utility District, the Contra Costa Water District, and other areas are located in the Delta. Natural gas wells in the Delta fuel power plants and other energy uses. Wind turbines and other renewable power sources also are located in the Delta. Electric transmission lines and fuel pipelines cross the Delta to carry energy to energy users. Communications towers support broadcasting and telecommunications. These facilities need to be planned carefully to avoid conflicts with water supply, ecosystem restoration, or flood management facilities, and existing and planned land uses.

Delta Investment Fund

In 2009, the Legislature established a Delta Investment Fund in the State Treasury (Public Resources Code section 29778.5). DPC's ESP recommends forming a regional agency to manage the fund, and to implement and facilitate economic development efforts, either through expansion of the DPC's authority or creation of a joint powers authority composed of local governments.

Agriculture in the Delta

Agriculture is among the qualities that define the Delta as a place. This section provides additional detail about the role of agriculture and discusses issues such as subsidence and water quality that must be considered in policy making. The Delta's initial reclamation created farmland, and ongoing maintenance of its levees and water controls allows for continued farming in the region. Agriculture dominates the Delta landscape, as shown on Figure 5-3, and provides the setting for Delta residents' communities, homes, and job sites. Agriculture benefits from the Delta's productive soils, special climate, and abundant water. Delta farms provide a local source of nutritious food and forage for nearby dairies. Farming, food processing, and related industries contribute significantly to the economy, particularly in the Delta's Primary Zone, where they predominate economic output, employment, and value-added activities. Characteristic local crops, such as pears, asparagus, and dried beans, are celebrated at annual festivals and county fairs.

Agriculture in the Delta depends on high-quality farmland. Prime farmlands with the best soils comprise about 400,600 acres, close to 85 percent of all farmland in the Delta. Another 101,760 acres are unique farmland, farmland of statewide or local importance, or farmland of potential local importance (DOC 2009). Because of the fertile peat soils and the moderating marine influence, Delta agriculture's per-acre yields are almost 50 percent higher than the state's average (Trott 2007). As described in Chapters 3 and 4, reliable, abundant fresh water is also an essential contributor to Delta agriculture.

Agricultural Land Use in the Delta

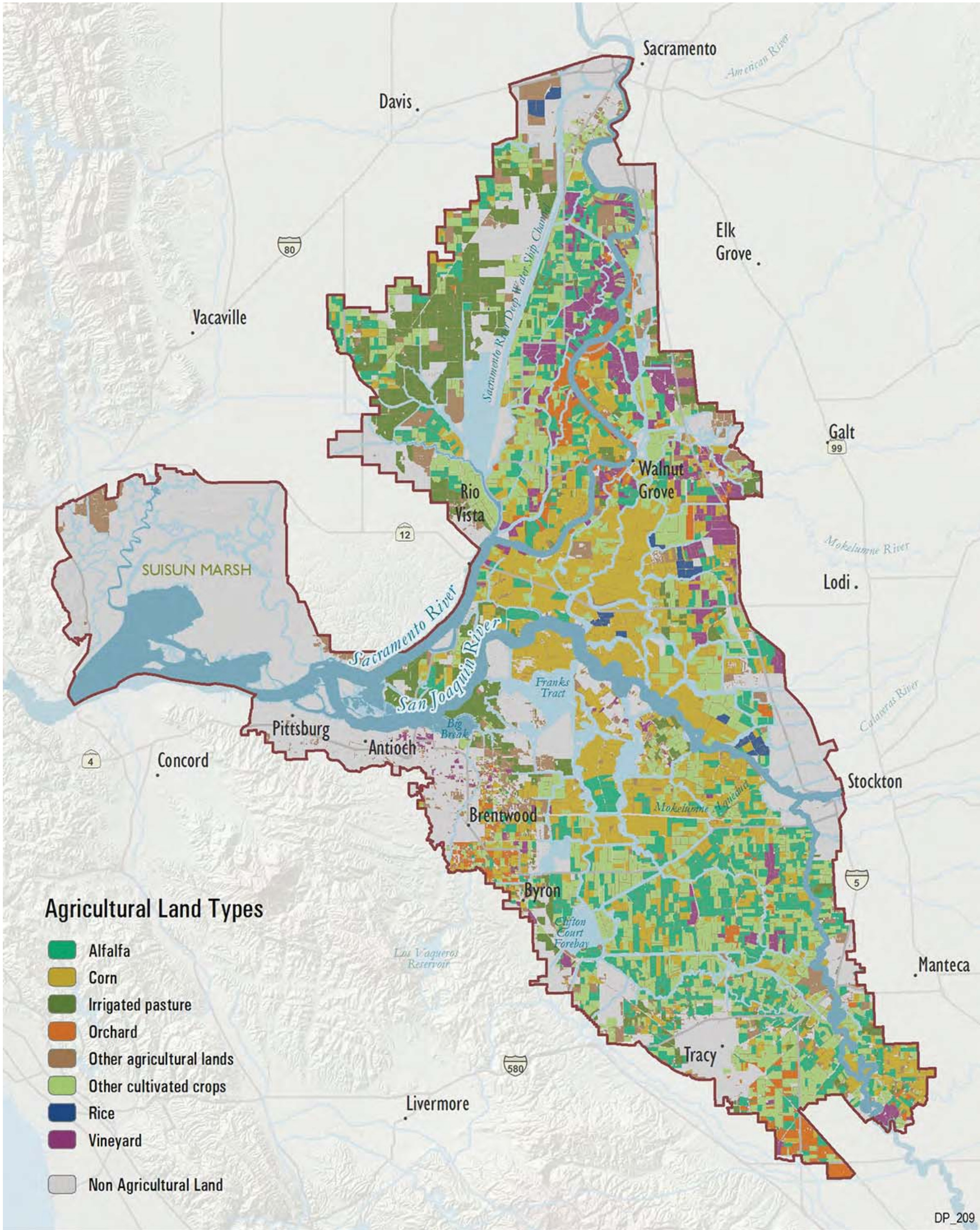


Figure 5-3 *Source: DOC 2008*

Field crops and pasture cover most of the Delta agricultural acreage. In 2010, about one-fourth of farmland in the Delta was corn, much of which is harvested as silage and used in the dairy industry. Alfalfa, the second most widely planted crop, covered about 20 percent of the Delta's farmland. Together, these croplands comprise about 10 percent of the irrigated acreage supporting California's dairy industry. Barley, wheat, and oats were planted on about 69,000 acres. About 41,000 acres of irrigated pasture are used by livestock. Truck crops, including processing tomatoes, asparagus, cucumbers, potatoes, pumpkins, and melons, covered nearly 52,500 acres. Almost 31,000 acres support vineyards. Orchards of pears, almonds, walnuts, and cherries grow on about 17,000 acres (DPC 2012b).

The DPC ESP forecasts that high-value crops, including truck, deciduous, and vineyard crops, are likely to increase in coming decades, potentially increasing farm incomes and economic output. Lower value crops, including field and grain crops, are likely to decline. Some traditional Delta crops are losing markets due to changing consumer preferences and competition from other regions. For example, the Bartlett pear market peaked around World War I, when 50 percent of all Bartletts were produced in California, mainly in the Delta. Until 1930, the Delta was also the world's asparagus capital, producing 90 percent of the globe's production (DPC 2011). Today, a mere 7,200 acres of asparagus fields remain. But growth of wine grapes and other crops, and expansion of local crop processing, particularly winemaking, could enhance agriculture's contribution to the Delta's economy (DPC 2012b). Urban development, ecosystem restoration, or flood control facilities that take farmland out of production could hasten the decline of agriculture.

Value is added to Delta crops when they are processed for ease of use or shipment. Examples include food and beverage manufacturing, such as the tomato canneries or sugar processors that were prominent twentieth century Delta businesses. Today's opportunities include winemaking or emerging sectors such as olive pressing. Special local markets that serve consumers in the Delta counties or Bay Area, such as farm-to-school programs or community-supported agriculture, also may provide new markets for some Delta crops. Facilities that improve the region's capacity to aggregate and distribute its crops to these local markets may enhance Delta agriculture (SACOG 2011). Consistent interpretation and application of regulations about food processing and distribution could help local producers and distributors establish facilities (Sumner and Rosen-Molina 2011).

Protecting Productive Farmlands

Although agriculture is the principal land use in the Delta, the total area of agricultural lands (including fallow lands) in the combined Delta and Suisun Marsh area has declined from about 549,420 acres in 1984[1] to 460,450 acres in 2008, and the percentage of agricultural land has decreased from about 65 percent of this combined area in 1984 to about 55 percent in 2008 (DOC 1984, DOC 1988, DOC 1990, DOC 2008). An additional 28,000 acres of farmland may be lost in the near future under current local government general plans. The Delta Plan acknowledges this loss since it focuses growth within existing city boundaries. However, any further loss of farms to urban development is unacceptable. The continued viability of agriculture in the Delta will require the protection of sufficient farmland and fresh water to support commercially viable operations and provide ways for agriculture to coexist with habitat restoration. Policies DP P1 and DP P2 acknowledge the importance of protecting these lands. The DPC and local governments play key roles in the protection of these lands.

The loss of some farmland to urbanization, habitat, and flooding is inevitable, the DPC ESP concludes; but continued shifts to higher-valued crops and value-added activities, as well as planning restoration in appropriate locations, may help compensate if land loss is not too great. As described in Chapter 4, elevations, locations, and other factors are key

[1] Data for Sacramento and San Joaquin counties were not available in the 1984 DOC report; thus, data for these counties were taken from the 1988 and 1990 reports, respectively.

determinants of the optimal sites for ecosystem restoration. When these restoration areas include farmlands, achieving the coequal goals of restoring the Delta ecosystem and improving water supply reliability may make some loss of productive agricultural lands unavoidable. Some conveyance alternatives could take farmland out of production, too. Improving flood control facilities may also unavoidably affect some farmland.

Subsidence

The reclamation of Delta islands and their cultivation for agriculture initiated a process of land subsidence, mostly due to oxidation of peat soils, but also from wind erosion. Drainage and cultivation dried the saturated peat, reducing its volume by approximately 50 percent. Early cultivation practices also included burning, which further reduced the volume of the soil and altered its structure. Over time, long-term oxidation reduced about 2.6 to 3.3 billion cubic yards of these peaty soils to small particles and gases. As a result, much of the central Delta today is below sea level, with some islands 12 to 15 feet below sea level. Many islands now more closely resemble bowls surrounded by water, with high sides defined by levees and deep, hollowed-out bases. Although subsidence has slowed in some areas, other regions of the Delta continue to lose soil to oxidation and wind erosion at a rate of 5 to 15 tons/acre/year. It is projected that some areas of the Delta could subside an additional 2 to 4 feet by 2050 (Deverel and Leighton 2010), resulting in the loss of up to 350 to 500 million cubic yards of soil at a rate of 5 to 15 tons/acre/year (see Figure 5-4).

Land subsidence impairs Delta agriculture, not only because of soil loss, but also by increasing the difficulty of maintaining drainage systems and levees. As described in Chapter 7, subsidence makes levees less stable and increases flood risks. The costs to recover a flooded island could be great. Some suggest that many islands would cost more to reclaim after flooding than the value of the land for agriculture. In 1998, 4,200 acres of farmland were lost when Liberty Island flooded and was not reclaimed (Reclamation District 2093 2009). Other once-farmed islands that were not reclaimed after flooding include Big Break, Franks Tract, and Mildred Island (Suddeth et al. 2010).

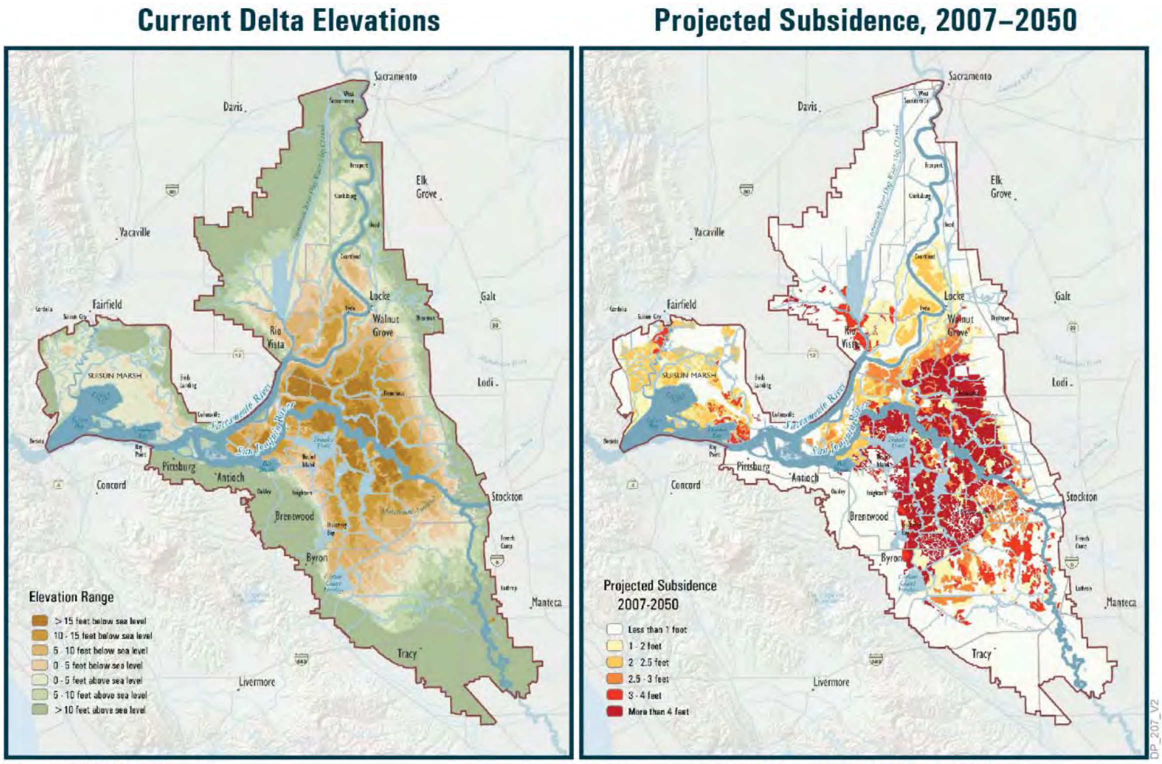
Oxidation of peat soils also liberates vast quantities of carbon dioxide (CO_2), contributing to global warming (Armentano 1980). Oxidation of the Delta's agricultural soils emits about 4.4 to 5.3 million tons of CO_2 annually (Delta Conservancy 2012). For comparison, a typical 500-megawatt coal-fired power plant emits 3 million tons of CO_2 per year.

The potential to retire croplands on deeply subsided islands and manage them to rebuild peat and sequester carbon is sometimes pondered as an alternative to continued farming (Armentano 1980). State and federal agency investigations of alternative land management practices show that soils can be rebuilt, reversing subsidence and sequestering carbon, with some appropriately managed activities, such as tule farming (Miller 2008). Recent actions by the California Air Resources Board, under the California Global Warming Solutions Act of 2006 (Health and Safety Code section 38500 et seq.), provide for the development of a carbon market program, whereby certain activities may be considered acceptable for providing offset credits. Although this program is still in its initial stages, future opportunities may exist for Delta farmers to gain offset credits for growing plants that promote subsidence reversal and sequester carbon.

Agriculture and Water Quality

The DPC's ESP provides scenarios for how potential declines in water quality that could accompany some water conveyance, ecosystem restoration, or water quality actions could affect Delta agriculture. The potential for the agricultural economy to grow in the Delta will depend, in part, on the protection of the Delta's abundant fresh water and the policy response. Chapter 6 contains a detailed discussion of water quality and the Council's strategies for water quality.

Subsidence in the Delta



Source: DWR 2009

Source: adapted from Deverel and Leighton 2010

Figure 5-4

Oxidation of peat soils through natural processes and human activities has caused the land elevation in the Delta to drop. Much of the central Delta is now at or below sea level. Future subsidence has been projected in these areas. As subsidence progresses, levees must be continually maintained, strengthened, and periodically raised to support increasing hydraulic stress.

Wildlife-friendly Agriculture

Agriculture has the potential to coexist with and even enhance restoration of the Delta ecosystem despite the conversion of some farmland to habitat. Techniques that integrate management of agriculture and wildlife habitat, often called "wildlife-friendly agriculture," include crop rotations that include soil-building crops or fallowing; integrated pest management to reduce pesticides; cover crops; the strategic use of permanent crops, such as pasture, to reduce soil disturbance and oxidation; and conservation tillage for field and row crops (Trott 2007). Some native species have adapted to using agricultural lands as habitat in place of tidal marshes, grasslands, and seasonal wetlands. Rice and other flood-irrigated crops support a range of wildlife, especially waterfowl, shorebirds, wading birds, and giant garter snakes. Swainson's hawk, other raptors, and coyote feed on small mammals and ground-nesting birds that inhabit alfalfa fields and other irrigated pastures. Waste grain also provides food for species such as ring-necked pheasant and greater sandhill crane (Trott 2007).

To support Delta agriculture and species recovery, farmers in the Delta are encouraged to implement management practices to maximize habitat values. Some U.S. Department of Agriculture (USDA) programs provide financial incentives for landowners to manage natural areas on their properties, including the Wildlife Habitat Incentives Program, the Environmental Quality Incentives Program, and the Conservation Reserve Program. The DFW, U.S. Fish and Wildlife Service, and Delta Conservancy also can assist landowners who want to enhance wildlife habitat.

As described in Chapter 4, safe harbor agreements can assure these landowners that the presence of an endangered species on their property will not result in restrictions on activities on their land. Facilitating and creating standard rules for these agreements with Delta landowners may encourage more landowners to participate in conservation programs. Restoring wildlife and fish through wildlife-friendly agriculture can help achieve ecosystem restoration objectives while reducing the loss of farmland to habitat restoration.

Agritourism

Agritourism is another opportunity to add further value to the Delta economy from agricultural activities. Defined as recreational, educational, and other visits to working farms, agritourism is a small but fast-growing source of income for farms in the region and a growing segment of the Delta economy. In the Delta, agritourism destinations may include wineries, on-farm duck clubs, farm stands, and other places. Agritourism was estimated by USDA to generate $4 million in income for farms in the five Delta counties in 2007 (DPC 2012b). For farmers who choose to participate, agritourism can provide additional income, an opportunity to sell farm products directly to consumers, or alternative uses for unproductive lands or buildings. The Discover the Delta Foundation's Delta Discovery Center combines several agritourism functions, including a produce stand, wine sales, and interpretive features that teach people about the Delta's importance (Sumner and Rosen-Molina 2011).

Recreation and Tourism in the Delta

This section provides an overview of recreation and tourism in the Delta. DPC estimates that about 12 million activity days of recreation occur in the Delta annually (DPC 2012b). Recreational users originate from both within and outside the Delta. Visitors value the wide expanses of open land, interlaced waterways, historic towns, and the lifestyle offered by the Delta. The region's mix of land and water offers diverse recreation experiences and facilities, including fishing, boating, birdwatching, other nature activities, hunting, enjoying restaurants, campgrounds, picnic areas, and historic towns and buildings. Recreation also benefits from the Delta's open, agricultural landscape, with its scenic vineyards, orchards, and farmsteads. These are often backed by views of Mt. Diablo or the Montezuma Hills on the horizon, which provide a setting for outdoor photography, a scenic bike ride, or a drive along the Delta's roads. Special events draw visitors to taste local produce and wine, and learn about this unique place. These recreation opportunities are described in more detail in the DPC's ESP and in the Recreation Proposal that California State Parks submitted to the Council and DPC pursuant to Water Code section 85301(c)(1). Figure 5-5 shows the locations of State parks and other protected lands in the Delta. Figure 5-6 shows the variety and distribution of some of these opportunities in the Delta.

State Parks and Other Protected Lands

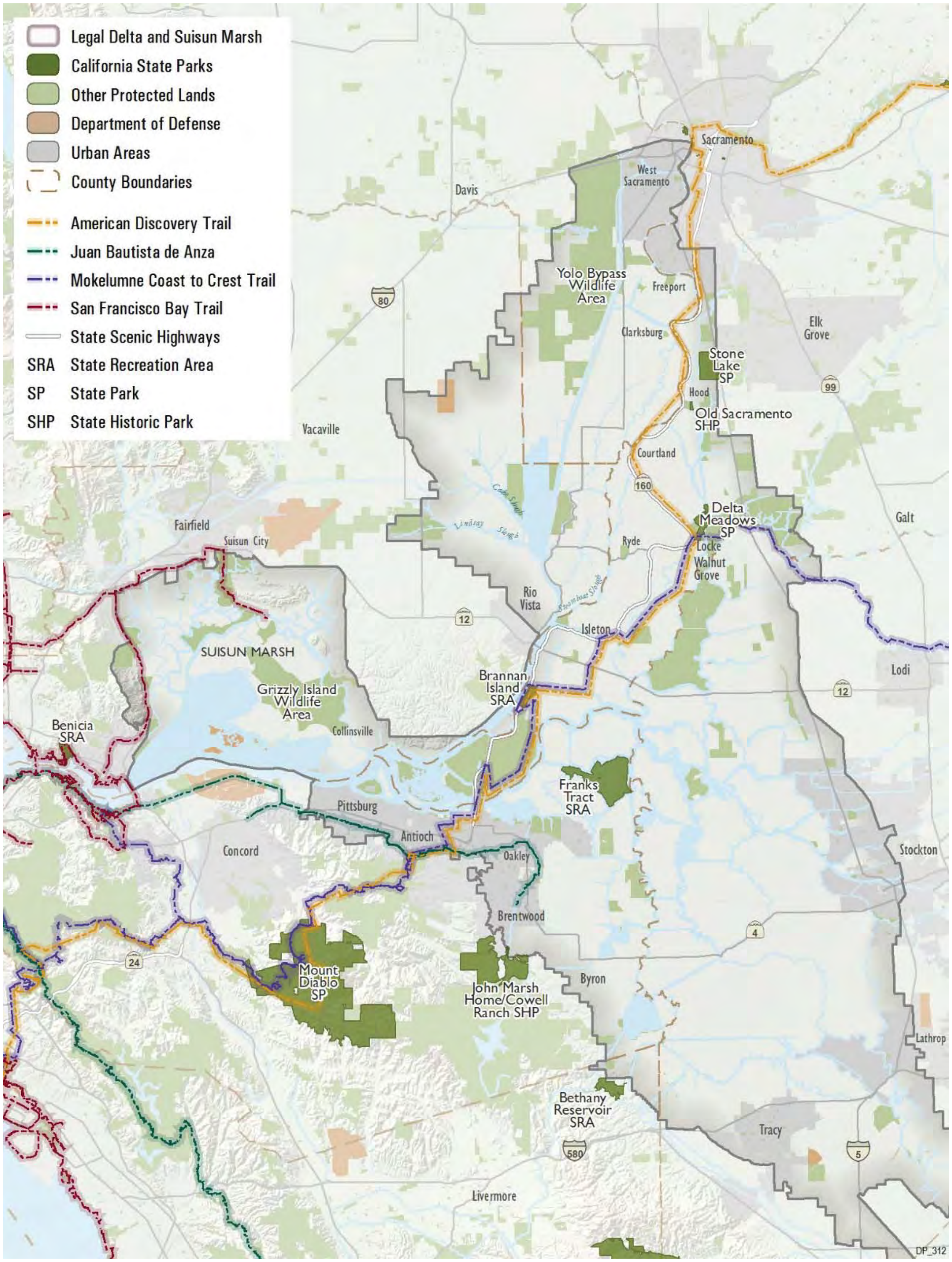


Figure 5-5 *Source: California State Parks 2011*

Major Delta Resources and Recreation

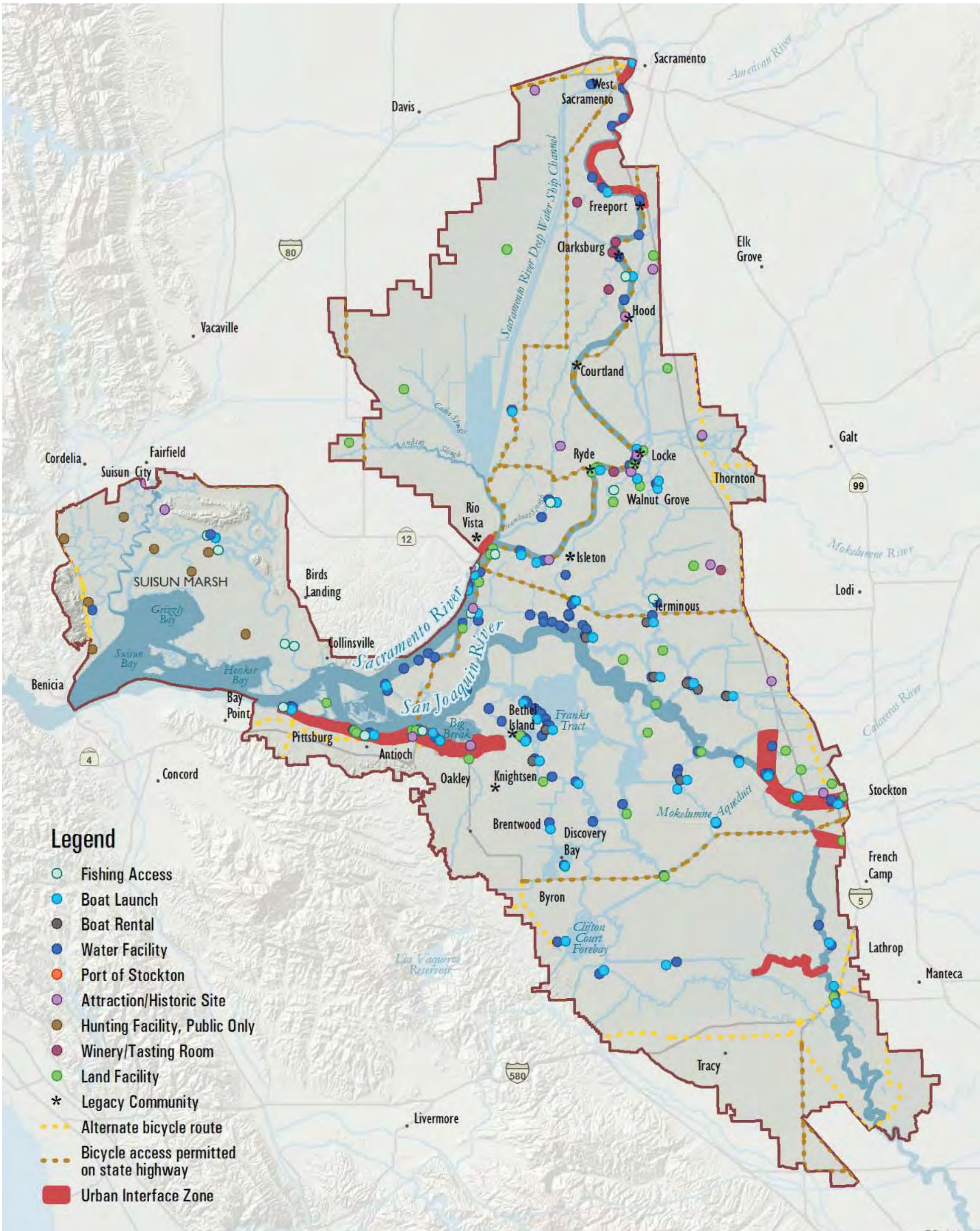


Figure 5-6

Sources: California Chambers and Visitors Bureau 2010, California Resources Agency 2007, DPC 2006, Discover the Delta Foundation 2010, California Department of Fish and Game 2009

The DPC ESP and the California State Parks Recreation Proposal both foresee opportunities to increase recreation and tourism in the Delta as the population of surrounding areas grows, especially with improved branding and marketing. Both reports emphasize improvements of "gateways" to the region on the Delta's urban edges and "base camps," focal points for visitors inside the Delta at destinations such as resorts, legacy communities, and parks. They also recommend diversifying dispersed outdoor recreation "adventures" at points of interest and activity areas for boaters, nature area visitors, and others. Ecosystem restoration, as described in Chapter 4, can enhance opportunities for nature-based recreation and boating, especially by nonmotorized boats, according to both reports.

The California State Parks Recreation Proposal recommends enhancing State parks and other State agencies' properties and programs to create a network of recreation areas in the Delta, and encourages improvement of public access along the shorelines of growing Delta communities, consistent with Water Code section 85022(d)(3). It recommends that recreation improvements be provided in new water management and habitat restoration projects unless they are inconsistent with the project purposes, in conformance with Water Code sections 11910–11915.5, or public safety. DPC's ESP also recommends that recreation facilities be included in ecosystem restoration projects when feasible. Additionally, the ESP emphasizes growing the tourism and recreation economy through private, visitor-serving businesses, and collaboration and partnerships between public- and private-sector recreation providers.

Future prospects for Delta recreation and tourism will be strongly influenced by decisions about the Delta ecosystem, water quality, levee improvements, and governance, including land use and environmental standards. The Bay Delta Conservation Plan (BDCP), Delta water quality plans, levee investments, and other decisions yet to be made can all significantly affect recreation and tourism.

Boating

Navigable waterways in the Delta and Suisun Marsh are available for public access and provide many recreational opportunities. Boating activities total more than 6.4 million visitor days annually, composed of 2.13 million annual boat trips with a projected growth to 8 million visitor days by 2020, according to the Department of Boating and Waterways. Almost 100 marinas, with more than 11,000 boat slips, and almost 60 launch ramp lanes support boating in the Delta and Suisun Marsh (DBW 2002). Popular activities include powerboating on the Sacramento and San Joaquin rivers, paddling sloughs and channels in canoes and kayaks, and sailing on the open water of Suisun and Honker bays. About 116,000 boats are registered in the five Delta counties, creating a large pool of potential recreationists (California State Parks 2011).

Public Recreation Lands

Public lands comprise about 10 percent of the Delta. State and local parks, State or national wildlife areas and refuges, ecological preserves, and other public lands provide important sites for relaxing outdoors, a family picnic, camping, and other outdoor recreation in the Delta. California State Parks owns three properties in the Delta: Brannan Island State Recreation Area and properties at Locke Boarding House-Delta Meadows and Stone Lakes. The DFW and the State Lands Commission also manage important State-owned recreation areas. The largest State ownerships are the California Department of Water Resources (DWR) lands on Sherman and Twitchell islands, which are available seasonally for hunting.

Table 5-3 summarizes the agency responsibilities, recreation-related opportunities, and examples of recreation facilities in the Delta managed by the State. City and county parks, including those of the East Bay Regional Park District, also provide important public recreation areas. These public lands are increasingly important for Delta recreation because privately owned riverbanks and levees, which comprise most of the Delta's shoreline, are increasingly posted to prevent trespass, reducing access to rivers and sloughs for bank fishing, nature observation, and outdoor relaxation.

State Agencies with Responsibility for Recreation in the Delta

TABLE 5-3

State Agency Name and Role	Recreation-related Facilities and Opportunities	Delta and Suisun Marsh Examples
California State Parks offers high-quality outdoor recreation and educational opportunities, protects natural and cultural resources, awards grants for local parks, and oversees the California Recreational Trails System.	Day-use picnic areas, campgrounds, marinas, trails, excursion railroads, interpretive services, heritage resource protection, restrooms	Brannan Island State Recreation Area, Old Sacramento State Historic Park, American Discovery Trail
California Department of Fish and Wildlife manages hunting and fishing; operates public lands for wildlife conservation, hunting, fishing, environmental education, and nature study; and encourages private conservation.	Ecological reserves, wildlife areas, boat launches, nature-based recreation and events, fish hatcheries	Woodbridge Ecological Reserve, Grizzly Island Wildlife Area, Clarksburg boat launch
California Department of Boating and Waterways provides public recreational boating facilities on public lands, marine patrol law enforcement, boating safety and clean and green education, and controls of aquatic invasive species.	Public boat launching facilities, public visitor docks, boat-in day use and overnight facilities, vessel pumpout facilities, floating restrooms, floating campsites	Antioch Marina, Brannan Island State Recreation Area, Sherman Island, Belden's Landing, Bethany Reservoir, and Rio Vista boat launch facilities
California Department of Transportation operates state highways, historic bridges, and ferries, and designates state scenic highways.	Scenic highways, ferries, historic bridges	State Highway 160, J-Mack Ferry, Steamboat Slough Bridge
California Department of Water Resources manages California's water resources, including State Water Project reservoirs, dams, land, and waterways available for recreation use.	Reservoirs, water conveyance infrastructure (canals, diversion sites, waterway flows), flood control projects, habitat management sites and facilities	Bethany Reservoir, Sacramento River flows, Fremont Weir, Suisun Marsh salinity control structure, Dutch Slough habitat restoration project
State Lands Commission has jurisdiction over hundreds of miles of waterways in the Delta and issues leases for instream recreation infrastructure.	Navigable waterways, submerged lands, dock and pier leases	Threemile Slough, Walnut Grove Public Dock

State Agencies with Responsibility for Recreation in the Delta

TABLE 5-3

State Agency Name and Role	Recreation-related Facilities and Opportunities	Delta and Suisun Marsh Examples
Sacramento-San Joaquin Delta Conservancy will implement ecosystem restoration, advance environmental protection, and support economic sustainability, including tourism and recreation.	Projects that enhance natural resources, cultural resources, or economic sustainability in a manner complementary to increased recreation, tourism, and environmental education	The Delta Plan, Bay Delta Conservation Plan, Economic Sustainability Plan, and Delta Conservancy Strategic Plan will guide projects
State Coastal Conservancy makes grants to purchase, protect, restore, and enhance coastal resources, including San Francisco Bay and Suisun Marsh, and to provide access to the shore.	Shoreline accessways, trails, habitat protection and restoration areas, farmland and open space protection	Rush Ranch protection, San Francisco Bay Area water trail, Marsh Creek stream restoration and trail
Delta Protection Commission adaptively manages the Delta's Primary Zone, including, but not limited to, agriculture, wildlife habitat, and recreation activities.	Heritage resource recognition and enhancement, agritourism program, regional trails	National Heritage Area feasibility study, Great California Delta Trail, Economic Sustainability Plan

Source: California State Parks 2011

Nature-based Recreation

Many recreation opportunities depend on the region's wildlife and fish, which support angling, nature observation, and hunting. Anglers pursue native fish, such as salmon and sturgeon, and introduced species such as striped bass, largemouth bass, and catfish. Some of the most visited public wildlife areas include the Yolo Bypass Wildlife Area, Lower Sherman Island, Calhoun and Acker Island, Stone Lakes National Wildlife Refuge, Cosumnes River Preserve, Solano County Land Trust's Jepson Prairie and Rush Ranch, and Suisun Marsh's wildlife management areas, including Grizzly Island and Joice Island. Hunting waterfowl is especially important in Suisun Marsh, most of which is managed by private duck clubs. Careful management of wildlife and fish is important to maintaining nature-based recreation, which can benefit from the restoration of fisheries and expansion of wildlife habitat.

Heritage Tourism

The Delta's legacy communities and other historic sites, from house museums to twentieth century industrial sites and weather-beaten marine facilities, attract history buffs and heritage tourists. Museums, nature centers, and interpretive programs draw visitors who want to learn about the Delta's natural and cultural resources. The region's productive farms and wineries, and its diverse ethnic heritage are attractions for food and wine tourism, and for community festivals and other special events. (Agritourism is discussed earlier in the Agriculture in the Delta section.)

Linking these areas and providing access to them are the Delta's waterways and roads. State Route 160 has a special role and provides visitors from metropolitan Sacramento and Contra Costa County with access to the Sacramento River, legacy communities, and the Delta's State parks. Its attractive rural landscape is reflected in its designation as a state scenic highway. California State Parks' Recreation Proposal recommends that the California Department of Transportation seek national scenic byway status for this route and prepare a scenic byway plan that would identify opportunities to improve signage, interpretation, and amenities for access, recreation, and nonautomobile circulation. A national scenic byway is a road recognized by the U.S. Department of Transportation for its archaeological, cultural, historic, natural, recreational, and/or scenic qualities. The program preserves and protects the nation's scenic but often less-traveled roads, and promotes tourism and economic development. Funding for byway-related projects is granted annually by the Federal Highway Administration. State Routes 4 and 12 are also important for recreational travel.

The American Discovery Trail, Mokelumne Coast-To-Crest Trail, and Great Delta Trail (Public Resources Code section 5852 et seq.) are State trails that can provide recreational access for bicyclists, hikers, and others. DPC's ESP and California State Parks' Recreation Proposal also recommend a system of water trails to guide boaters through the Delta's channels.

POLICIES AND RECOMMENDATIONS

The policies and recommendations presented in this section address the unique values that distinguish the Delta and make it a special region, and outline the Council's five core strategies for protecting and enhancing these values as follows:

- Designate the Delta as a special place worthy of national and state attention
- Plan to protect the Delta's lands and communities
- Maintain Delta agriculture as a primary land use, a food source, a key economic sector, and a way of life
- Encourage recreation and tourism that allow visitors to enjoy and appreciate the Delta and that contribute to its economy
- Sustain a vital Delta economy that includes a mix of agriculture, tourism, recreation, commercial and other industries, and vital components of state and regional infrastructure

Protecting the Delta also depends on the strategies to reduce flood and other risks, as detailed in Chapter 7.

Designate the Delta as a Special Place

Designating the Delta as a special place can build public recognition of the Delta and its unique resources. The DPC proposes to seek the Delta's designation as an NHA to recognize and promote "Delta-as-a-Place" and to cultivate appreciation and understanding of the Delta. The DPC recommends that the NHA include the legal Delta and Suisun Marsh, as well as adjoining areas in Rio Vista and the Carquinez Strait.

The proposed NHA's vision is "a regional network of partner sites, with interpretive/educational components, that will be linked where possible and serve as the primary attractions, on existing public properties or on private properties with the voluntary consent and involvement of the landowners." The NHA's goals are to "brand the Delta as a region of national significance to educate the public about 'Delta-as-a-Place,' and build more support for preserving, protecting, and enhancing the Delta." Other goals relate to economic development, public access, historic preservation, interpretation, and more.

Although State Route 160 is already recognized as a state scenic highway, national scenic byway status under the U.S. Department of Transportation and a scenic byway plan would provide opportunities to improve signage, interpretation, and amenities for access, recreation, and nonautomobile circulation. The byway program would qualify the route for special funding from the Federal Highway Administration.

Problem Statement

Because the Delta is different, it is sometimes unappreciated and misunderstood. Without a clear message about the Delta and its importance, the region and its resources can suffer from inattention or misuse. If the Delta's unique cultural, recreational, and agricultural values are not recognized, they are unlikely to be protected and enhanced.

Policies

No policies with regulatory effect are included in this section.

Recommendations

DP R1. Designate the Delta as a National Heritage Area

The Delta Protection Commission should complete its application for designation of the Delta and Suisun Marsh as a National Heritage Area, and the federal government should complete the process in a timely manner.

DP R2. Designate State Route 160 as a National Scenic Byway

The California Department of Transportation should seek designation of State Route 160 as a National Scenic Byway, and prepare and implement a scenic byway plan for it.

Plan to Protect the Delta's Lands and Communities

Protecting the Delta's lands and communities involves a multipronged policy approach. In the coming years and decades, the Delta will face increasing pressures from a growing population, changes in commodity markets, and changes in climate and sea level that will require flexibility and adaptation.

Some changes will be driven by the Delta's role in California's water systems, and they will be required to meet statewide goals of restoring the Delta's ecosystem and improving water supply reliability. These and other changes will shape how the Delta's communities and history are preserved, guide new development, affect recreation and tourism, and influence agriculture, business expansion, and economic development.

The policies and recommendations below reflect the Council's approach to fostering land uses and development that are resilient to these changes, reduce risks to people and property, adjust to changing conditions, and recover readily from distress. Protecting the Delta also depends on sustaining its economic vitality and maintaining the region as a desirable place to live, do business, and visit.

The maps that the following policies and recommendations reference are based on the best information available to the Council, but they may not precisely match either the built environment or local government land use plans. Where uncertainty exists with respect to the boundaries of areas referenced in these policies, the following rules should be considered in making determinations:

- The areas depicted should be assumed to generally follow parcel lines or other major landmarks, such as a road or highway, or river and stream.
- Local government general plans, including their land use diagrams, in effect at the time of the Delta Plan's adoption, may be consulted.

Problem Statement

Poorly sited or designed projects can detract from the values that contribute to the Delta's distinctive character, including its primarily rural, agricultural landscape; conflict with established uses, including farming and tourism; reduce opportunities for ecosystem restoration; or increase flood risks. By limiting significant new development to areas currently designated for development in cities, their SOIs, and unincorporated towns, the Council intends to foster a land use pattern that enhances the Delta's unique sense of place by protecting agriculture and the open, rural landscape while reducing risks to people and property. Outside the urban areas and towns mentioned above, in areas designated as agriculture, open space, recreation, natural preserve or marsh, or public/quasi-public, minor projects that are consistent with local land use designations, such as farmworker housing in areas designated as agriculture, are also appropriate. Similar limitations are already in place in the Primary Zone of the Delta, where the Delta Protection Act requires that new development must be consistent with the DPC's Land Use and Resource Management Plan. Additional protections for the Secondary Zone are needed. Diligent local *implementation of State law regarding flood protection in urban, urbanizing, and rural lands, and the National Flood Insurance Program will provide complementary flood protection benefits. New residential subdivisions, if any, in rural areas will also need to include adequate flood protection, as described in RR P2.*

Therefore, outside the urban areas and towns mentioned above, in areas that are designated as agriculture, open space, recreation, natural preserve or marsh, or public/quasi-public, the Council intends to enable counties to move forward with approval of minor projects that are consistent with these designations, such as farmworker housing in areas designated as agriculture. However, any proposals to site new residential development in rural areas will need to include adequate flood protection, as described in RR P2.

Careful planning for development in legacy communities is needed to protect their unique character and overcome barriers to investment. The Delta's urban areas will also continue to need sites for housing, employment, and businesses, supported by adequate roads and other infrastructure. Water management facilities, ecosystem restoration actions, and flood control projects will need to be accommodated in the Delta, too. Avoiding condemnation of property for water management, ecosystem restoration, and flood management facilities, when feasible, can promote better relations with Delta residents and local governments.

Policies

The appendices referred to in the policy language below are included in Appendix B of the Delta Plan.

DP P1. Locate New Urban Development Wisely

(a) New residential, commercial, and industrial development must be limited to the following areas, as shown in Appendix 6 and Appendix 7:

(1) Areas that city or county general plans as of May 16, 2013, designate for residential, commercial, and industrial development in cities or their spheres of influence;

(2) Areas within Contra Costa County's 2006 voter-approved urban limit line, except no new residential, commercial, and industrial development may occur on Bethel Island unless it is consistent with the Contra Costa County general plan effective as of May 16, 2013;

(3) Areas within the Mountain House General Plan Community Boundary in San Joaquin County; or

(4) The unincorporated Delta towns of Clarksburg, Courtland, Hood, Locke, Ryde, and Walnut Grove.

(b) Notwithstanding subsection (a), new residential, commercial, and industrial development is permitted outside the areas described in subsection (a) if it is consistent with the land uses designated in county general plans as of May 16, 2013, and is otherwise consistent with this Chapter.

(c) For purposes of Water Code section 85057.5(a)(3) and section 5001(j)(1)(E) of this Chapter, this policy covers proposed actions that involve new residential, commercial, and industrial development that is not located within the areas described in subsection (a). In addition, this policy covers any such action on Bethel Island that is inconsistent with the Contra Costa County general plan effective as of May 16, 2013. This policy does not cover commercial recreational visitor-serving uses or facilities for processing of local crops or that provide essential services to local farms, which are otherwise consistent with this Chapter.

(d) This policy is not intended in any way to alter the concurrent authority of the Delta Protection Commission to separately regulate development in the Delta's Primary Zone.

23 CCR Section 5010
NOTE: Authority cited: Section 85210(i), Water Code.
Reference: Sections 85020, 85022, 85300, 85302, and 85305, Water Code.

DP P2. Respect Local Land Use When Siting Water or Flood Facilities or Restoring Habitats

(a) Water management facilities, ecosystem restoration, and flood management infrastructure must be sited to avoid or reduce conflicts with existing uses or those uses described or depicted in city and county general plans for their jurisdictions or spheres of influence when feasible, considering comments from local agencies and the Delta Protection Commission. Plans for ecosystem restoration must consider sites on existing public lands, when feasible and consistent with a project's purpose, before privately owned sites are purchased. Measures to mitigate conflicts with adjacent uses may include, but are not limited to, buffers to prevent adverse effects on adjacent farmland.

(b) For purposes of Water Code section 85057.5(a)(3) and section 5001(j)(1)(E) of this Chapter, this policy covers proposed actions that involve the siting of water management facilities, ecosystem restoration, and flood management infrastructure.

23 CCR Section 5011
NOTE: Authority cited: Section 85210(i), Water Code.
Reference: Sections 85020, 85022, 85054, 85300, and 85305, Water Code.

Recommendations

DP R3. Plan for the Vitality and Preservation of Legacy Communities

Local governments, in cooperation with the Delta Protection Commission and Delta Conservancy, should prepare plans for each community that emphasize its distinctive character, encourage historic preservation, identify opportunities to encourage tourism, serve surrounding lands, or develop other appropriate uses, and reduce flood risks.

DP R4. Buy Rights of Way from Willing Sellers When Feasible

Agencies acquiring land for water management facilities, ecosystem restoration, and flood management infrastructure should purchase from willing sellers, when feasible, including consideration of whether lands suitable for proposed projects are available at fair prices.

DP R5. Provide Adequate Infrastructure

The California Department of Transportation, local agencies, and utilities should plan infrastructure, such as roads and highways, to meet needs of development consistent with sustainable community strategies, local plans, the Delta Protection Commission's Land Use and Resource Management Plan for the Primary Zone of the Delta*, and the Delta Plan.*

DP R6. Plan for State Highways

The Delta Stewardship Council, as part of the prioritization of State levee investments called for in Water Code section 85306, should consult with the California Department of Transportation as provided in Water Code section 85307(c) to consider the effects of flood hazards and sea level rise on State highways in the Delta.

DP R7. Subsidence Reduction and Reversal

The following actions should be considered by the appropriate State agencies to address subsidence reversal:

- *State agencies should not renew or enter into agricultural leases on Delta or Suisun Marsh islands if the actions of the lessee promote or contribute to subsidence on the leased land, unless the lessee participates in subsidence reversal or reduction programs.*
- *State agencies currently conducting subsidence reversal projects in the Delta on State-owned lands should investigate options for scaling up these projects if they have been deemed successful. The California Department of Water Resources should develop a plan, including funding needs, for increasing the extent of their subsidence reversal and carbon sequestration projects to 5,000 acres by January 1, 2017.*
- *The Delta Stewardship Council, in conjunction with the California Air Resources Board (CARB) and the Delta Conservancy, should investigate the opportunity for the development of a carbon market whereby Delta farmers could receive credit for carbon sequestration by reducing subsidence and growing native marsh and wetland plants. This investigation should include the potential for developing offset protocols applicable to these types of plants for subsequent adoption by the CARB.*

Maintain Delta Agriculture

Agriculture is the principal land use in the Delta; however, in recent decades, the total area of agricultural lands has declined, as has the overall percentage of lands in agricultural use. The continued viability of agriculture in the Delta will require the protection of sufficient farmland and fresh water to support commercially viable operations and provide ways for agriculture to coexist with habitat restoration. Policies DP P1 and DP P2 acknowledge the importance of protecting these lands. Farming in the Delta will have to respond to changing conditions and new challenges in the coming years. Among these challenges are shifting commodity markets and consumer demand, changes in climate and water supplies, and subsidence of reclaimed agricultural lands. To support both Delta agriculture and species recovery, farmers in the Delta are encouraged to implement "wildlife-friendly" management practices to maximize habitat values. Restoring wildlife and fish through wildlife-friendly agriculture can help achieve ecosystem restoration objectives while reducing the loss of farmland to habitat restoration. Agritourism is a small but fast-growing source of income for farms in the region. It is another opportunity to add further value to the Delta economy from agricultural activities.

Problem Statement

Agriculture in some parts of the Delta is threatened by urbanization, subsidence, and changing markets due to increased competition from other countries and regions, and shifting consumer preferences. The impacts from water conveyance facilities, ecosystem restoration, changing water quality, and flood management plans are yet to be determined, but rapid and significant changes could disrupt agriculture. Farmers are concerned that regulations and other barriers to conducting business and using their land also threaten the continued viability of agriculture.

Policies

No policies with regulatory effect are included in this section.

Recommendations

DP R8. Promote Value-added Crop Processing

Local governments and economic development organizations, in cooperation with the Delta Protection Commission and the Delta Conservancy, should encourage value-added processing of Delta crops in appropriate locations.

DP R9. Encourage Agritourism

Local governments and economic development organizations, in cooperation with the Delta Protection Commission and the Delta Conservancy, should support growth in agritourism, particularly in and around legacy communities. Local plans should support agritourism where appropriate.

DP R10. Encourage Wildlife-friendly Farming

The California Department of Fish and Wildlife, the Delta Conservancy, and other ecosystem restoration agencies should encourage habitat enhancement and wildlife-friendly farming systems on agricultural lands to benefit both the environment and agriculture.

Encourage Recreation and Tourism

The Delta region offers diverse recreation experiences and facilities such as fishing, boating, birdwatching, other nature activities, hunting, campgrounds, parks and picnic areas, and historic towns and buildings. DPC and California State Parks foresee opportunities to improve and increase recreation and tourism in the Delta. Both agencies recommend improvements of "gateways" to the region on the Delta's urban edges and "base camps" inside the Delta at destinations such as resorts, legacy communities, or parks that are focal points for visitors. Building on the reports of the DPC and California State Parks, the Council recommends protecting and improving existing recreation opportunities while seeking ways of providing new, and better coordinated, opportunities. Ecosystem restoration, as described in Chapter 4, can also enhance opportunities for nature-based recreation and boating. Future prospects for recreation and tourism will be influenced by decisions about the Delta ecosystem, water quality, levee improvements, and governance, including land use and environmental standards. The BDCP, Delta water quality plans, levee investments, and other decisions yet to be made can all significantly affect recreation and tourism.

Problem Statement

Recreation opportunities abound, but many have not been fully developed due to inadequate visitor information, aging and inadequate facilities, and restricted access to public lands. Limited cooperation in marketing, planning, and public-private partnerships between public recreation providers, other government land managers, businesses, and others hinders recreation and tourism, and impedes expansion of visitor-serving businesses.

Policies

No policies with regulatory effect are included in this section.

Recommendations

DP R11. Provide New and Protect Existing Recreation Opportunities

Water management and ecosystem restoration agencies should provide recreation opportunities, including visitor-serving business opportunities, at new facilities and habitat areas whenever feasible; and existing recreation facilities should be protected, using California State Parks' Recreation Proposal for the Sacramento-San Joaquin Delta and Suisun Marsh *and Delta Protection Commission's* Economic Sustainability Plan for the Sacramento-San Joaquin Delta *as guides.*

DP R12. Encourage Partnerships to Support Recreation and Tourism

The Delta Protection Commission and Delta Conservancy should encourage partnerships between other State and local agencies, and local landowners and business people to expand recreation, including boating, promote tourism, and minimize adverse impacts to nonrecreational landowners.

DP R13. Expand State Recreation Areas

California State Parks should add or improve recreation facilities in the Delta in cooperation with other agencies. As funds become available, it should fully reopen Brannan Island State Recreation Area, complete the park at Delta Meadows-Locke Boarding House, and consider adding new State parks at Barker Slough, Elkhorn Basin, the Wright-Elmwood Tract, and south Delta.

DP R14. Enhance Nature-based Recreation

The California Department of Fish and Wildlife, in cooperation with other public agencies, should collaborate with nonprofits, private landowners, and business partners to expand wildlife viewing, angling, and hunting opportunities.

DP R15. Promote Boating Safety

The California Department of Boating and Waterways should coordinate with the U.S. Coast Guard and State and local agencies on an updated marine patrol strategy for the region.

DP R16. Encourage Recreation on Public Lands

Public agencies owning land should increase opportunities, where feasible, for bank fishing, hunting, levee-top trails, and environmental education.

DP R17. Enhance Opportunities for Visitor-serving Businesses

Cities, counties, and other local and State agencies should work together to protect and enhance visitor-serving businesses by planning for recreation uses and facilities in the Delta, providing infrastructure to support recreation and tourism, and identifying settings for private visitor-serving development and services.

Sustain a Vital Delta Economy

Many of the policies and recommendations in this chapter deal with aspects of the Delta's economy such as maintaining agriculture and encouraging recreation and tourism. The Delta's economy also benefits from the surface transportation, utilities, and other infrastructure that crisscross the Delta to serve local needs and link the Delta to regional, national, and global markets. Facilities such as natural gas wells, wind turbines, other renewable power sources, electric transmission lines, and fuel pipelines need to be planned carefully to avoid conflicts with water supply, ecosystem restoration, or flood management facilities and existing and planned land uses. The ports at Stockton and West Sacramento are valuable assets to Delta communities and the state. Areas for water-dependent industries are located in Collinsville, Rio Vista, Pittsburg, and Antioch.

Problem Statement

Other economic opportunities in the Delta, including port and energy uses, could suffer if unplanned development, flooding, or other land uses interfere with them.

Policies

No policies with regulatory effect are included in this section.

Recommendations

DP R18. Support the Ports of Stockton and West Sacramento

The ports of Stockton and West Sacramento should encourage maintenance and carefully designed and sited development of port facilities.

DP R19. Plan for Delta Energy Facilities

The California Energy Commission and California Public Utilities Commission should cooperate with the Delta Stewardship Council as described in Water Code section 85307(d) to identify actions that should be incorporated in the Delta Plan by 2017 to address the needs of Delta energy development, storage, and distribution.

Timeline for Implementing Policies and Recommendations

Figure 5-7 lays out a timeline for implementing the policies and recommendations described in the previous sections. The timeline emphasizes near-term and intermediate-term actions.

Timeline for Implementing Policies and Recommendations

TIMELINE CHAPTER 5: Delta as an Evolving Place

	ACTION (REFERENCE #)	LEAD AGENCY(IES)	NEAR TERM 2012–2017	INTERMEDIATE TERM 2017–2025
POLICIES	Locate new urban development wisely (DP P1)	Local governments	●	●
POLICIES	Respect local land use when siting water or flood facilities or restoring habitats (DP P2)	Local governments and State agencies	●	●
RECOMMENDATIONS	Designate the Delta as a National Heritage Area (DP R1)	DPC	●	
RECOMMENDATIONS	Designate State Route 160 as a National Scenic Byway (DP R2)	Caltrans	●	
RECOMMENDATIONS	Plan for the vitality and preservation of legacy communities (DP R3)	Local governments, DPC, Delta Conservancy	●	
RECOMMENDATIONS	Buy rights of way from willing sellers when feasible (DP R4)	Local, State, and federal agencies	●	●
RECOMMENDATIONS	Provide adequate infrastructure (DP R5)	Caltrans, local agencies, and utility providers	●	●
RECOMMENDATIONS	Plan for State highways (DP R6)	Council, Caltrans	●	
RECOMMENDATIONS	Subsidence reduction and reversal (DP R7)	State agencies	●	
RECOMMENDATIONS	Promote value-added crop processing (DP R8)	Local governments and economic development organizations	●	●
RECOMMENDATIONS	Encourage agritourism (DP R9)	Local governments and economic development organizations	●	●
RECOMMENDATIONS	Encourage wildlife-friendly farming (DP R10)	DFW, Delta Conservancy	●	●
RECOMMENDATIONS	Provide new and protect existing recreation opportunities (DP R11)	Water management and ecosystem restoration agencies	●	●
RECOMMENDATIONS	Encourage partnerships to support recreation and tourism (DP R12)	DPC, Delta Conservancy	●	●
RECOMMENDATIONS	Expand State Recreation Areas (DP R13)	Parks	●	●
RECOMMENDATIONS	Enhance nature-based recreation (DP R14)	DFW	●	●
RECOMMENDATIONS	Promote boating safety (DP R15)	Boating and Waterways	●	
RECOMMENDATIONS	Encourage recreation on public lands (DP R16)	DWR, DFW, Delta Conservancy, Parks	●	
RECOMMENDATIONS	Enhance opportunities for visitor-serving businesses (DP R17)	Local governments and State agencies	●	●
RECOMMENDATIONS	Support the Ports of Stockton and West Sacramento (DP R18)	Ports of Stockton and West Sacramento	●	●
RECOMMENDATIONS	Plan for Delta energy facilities (DP R19)	California Energy Commission and PUC	●	

DP_344

Agency Key:

Boating and Waterways: California Department of Boating and Waterways
Delta Conservancy: Sacramento-San Joaquin Delta Conservancy
Caltrans: California Department of Transportation
Council: Delta Stewardship Council
DFW: California Department of Fish and Wildlife
DPC: Delta Protection Commission
DWR: California Department of Water Resources
Parks: California State Parks
PUC: California Public Utilities Commission

Figure 5-7

Science and Information Needs

Better information about recreation and tourism in the Delta and additional research into best practices for managing farmlands in the Delta can contribute to efforts to protect the Delta's unique values. These needs include the following:

- Surveys of Delta recreation at regular intervals, such as every 5 years, to inform marketing and planning for recreation and tourism
- Assessments of opportunities to control or reverse subsidence of farmland
- Analysis of land and water use by agriculture, including land ownership (resident vs. absentee; age of owner; size of holding, etc.), cropping patterns, soil types, and other factors to identify the Delta's agricultural regions, their competitive advantages, threats and opportunities
- Analysis of farm labor housing needs.

Issues for Future Evaluation and Coordination

Many Delta agencies and residents are concerned that the region's economy may suffer if agriculture or other uses decline significantly due to habitat restoration or water conveyance projects, especially the BDCP described in Chapter 3, or changes in State priorities for levee investment resulting from the studies recommended in Chapter 7. DPC's ESP forecasts adverse economic impacts from farmland loss based on a scenario of how these decisions may affect the region. Its Proposal to Protect the Delta as a Place recommends that the Delta Investment Fund support protection of the Delta economy, and be administered by the DPC and guided by an investment committee appointed by the DPC's commissioners (DPC 2012a). The Delta Conservancy will also play a role in some economic development efforts, as provided in Public Resources Code section 32322(b).

Because BDCP and new levee investment priorities are not yet complete, the magnitude of any impacts to farmland, other uses, or the Delta's economy cannot reasonably be forecast. If significant adverse impacts to the Delta economy do result from farmland losses or other impacts due to habitat restoration, water conveyance, or revised levee investment priorities, then measures to compensate for these losses may warrant consideration. This consideration should include creation of a regional agency to implement and facilitate economic development efforts, guided by the DPC's ESP. The agency's responsibilities could include the following:

- Branding and marketing the Delta
- Coordinating with counties and cities to encourage planning and infrastructure development that is aligned with economic sustainability strategies
- Providing regulatory assistance to reduce impediments to priority activities, including visitor-serving developments, dredging, levee construction, and ecosystem restoration, to reduce impediments and lower costs of these activities
- Encouraging value-added processing of Delta crops, agritourism, visitor-serving commercial businesses, and preservation of the historic buildings in legacy communities
- Recommending and overseeing expenditures from the Delta Investment Fund

Performance Measures

Development of informative and meaningful performance measures is a challenging task that will continue after the adoption of the Delta Plan. Performance measures need to be designed to capture important trends and to address whether specific actions are producing expected results. Efforts to develop and track performance measures in complex and large-scale systems like the Delta are commonly multiyear endeavors. The recommended output and outcome performance measures listed below are provided as examples and subject to refinement as time and resources allow. Final administrative performance measures are listed in Appendix E and will be tracked as soon as the Delta Plan is completed.

Recommended performance measures for protection and enhancement of the unique cultural, recreational, natural resources, and agricultural values of the Delta as an evolving place are described below.

Output Performance Measures

- Congress designates the Delta and Suisun Marsh as an NHA by January 1, 2014. (DP R1)
- Water management, ecosystem restoration, and flood management projects minimize conflicts with adjoining uses by including adequate mitigation measures to avoid adverse effects. (DP P2)
- Recreation facilities are included in new ecosystem restoration projects. (DP R9)
- The DWR and others increase the extent of their subsidence reversal and carbon sequestration projects to 5,000 acres by January 1, 2017. (DP R7)

Outcome Performance Measures

- No further rural farmland in the Delta is lost to urban development. (DP P1)
- Progress toward protecting the Delta legacy communities, as indicated by renovation of historic structures, floodproofing, and other reductions in flood hazards, and maintenance or growth of small businesses and population. (DP R3)
- Increasing tonnage of cargo and the number of jobs at the ports of Stockton and West Sacramento. (DP R18)

References

Armentano, T. V. 1980. Drainage of organic soils as a factor in the world carbon cycle. *BioScience* 30:825-30.

BCDC (San Francisco Bay Conservation and Development Commission). 1976. *Suisun Marsh Protection Plan*.

Beals, R. L. 1933. The ethnology of the Nisenan. *University of California Publications in American Archaeology and Ethnography* 31(6):335-410.

Bennyhoff, J. A., and D. A. Fredrickson. 1969. A proposed integrative taxonomic system for central California archaeology. *Toward a New Taxonomic Framework for Central California Archaeology*. Edited by R. E. Hughes, 15–24. Berkeley, CA: University of California, Archaeological Research Facility.

California Chambers and Visitors Bureau. 2010. Website used to identify recreational facilities in the Delta. http://www.californiadelta.org/index.htm. Accessed by The Dangermond Group. March.

California Resources Agency. 2007. Public, Conservation, and Trust Lands in California. Site accessed June 1, 2010. http://www.atlas.ca.gov/download.html#/casil/planning/landOwnership.

California Resources Agency. 2008. *Managing an Uncertain Future: Climate Change Adaptation Strategies for California's Water*. Sacramento, CA.

California State Parks. 2011. *Recreation Proposal for the Sacramento-San Joaquin Delta and Suisun Marsh*. Sacramento, CA.

City of Benicia. 2003. General Plan land use designations within Suisun Marsh. Digitized into GIS format by AECOM from City of Benicia Land Use map in 2012.

City of Fairfield. 2008. General Plan land use designations within Suisun Marsh. Received from the City of Fairfield in 2012.

City of Lathrop. 2012. General Plan Land Use map for the City of Lathrop. October. Site accessed March 14, 2013. http://www.ci.lathrop.ca.us/cdd/documents/.

City of Manteca. 2012. General Plan land use designations in GIS format. Received by Eryn Pimentel, AECOM, from Jeffrey Davis, City of Manteca, on September 4.

City of Rio Vista. 2001. General Plan land use designations in electronic non-GIS format. Site accessed 2009. http://www.riovistacity.com/images/Documents/chapter_04.pdf.

City of Sacramento. 2008. General Plan land use designations in electronic GIS format. Site accessed 2009. http://www.cityofsacramento.org/gis/data.html.

City of Stockton. 2011a. GIS layers for city spheres of influence and General Plan land use designations. Site accessed April 14, 2011. http://www.stocktongov.com/services/gis/mapdatDat.html.

City of Stockton. 2011b. General Plan land use designations in GIS format and General Plan land use designations within Suisun Marsh (digitized into GIS format by AECOM from Land Use map in 2012). Site accessed April 14, 2011. http://www.stocktongov.com/services/gis/mapdatDat.html.

City of Suisun City. 2011. General Plan land use designations within Suisun Marsh. Digitized into GIS format by AECOM from Land Use map in 2012.

City of Tracy. 2011a. General Plan land use designations provided in GIS format. Delivered via file transfer protocol from Victoria Lombardo, Senior Planner, City of Tracy, to Jessica Law, Urban and Environmental Planner, AECOM, on March 10, 2011.

City of Tracy. 2011b. City of Tracy Sphere of Influence provided in GIS format. Delivered via file transfer protocol from Victoria Lombardo, Senior Planner, City of Tracy, to Jessica Law, Urban and Environmental Planner, AECOM, on March 10, 2011.

City of West Sacramento. 2010. General Plan land use designations in GIS format. Site accessed December 28, 2010. http://www.cityofwestsacramento.org/services/gis/downloads.cfm.

Contra Costa County. 2008. GIS layer for Urban Limit Line for Contra Costa County. October. Site accessed June 27, 2011. http://ccmap.us/Details/asp?Product=134490.

Contra Costa County. 2010. GIS layer for City Spheres of Influence in Contra Costa County. January. Site accessed January 28, 2011. https://www.ccmap.us/catalog.asp?UserChoice=2&Layercntrl=0000000000000000000000.

DBW (California Department of Boating and Waterways). 2002. *Sacramento–San Joaquin Delta Boating Needs Assessment (2000-2020)*. Prepared by The Dangermond Group.

Delta Conservancy (Sacramento-San Joaquin Delta Conservancy). 2012. *Strategic Plan*. West Sacramento, CA.

Delta Vision (Delta Vision Blue Ribbon Task Force). 2008. *Delta Vision Strategic Plan*. October 17. http://deltavision.ca.gov/strategicplanningprocess/staffdraft/delta_vision_strategic_plan_standard_resolution.pdf.

Deverel, S. and D. Leighton. 2010. Historic, recent, and future subsidence, Sacramento-San Joaquin Delta, Calif., USA. *San Francisco Estuary and Watershed Science*. 8(2):23 p.

DFG (California Department of Fish and Game). 2009. GIS data. Planning for the Habitat Management, Preservation, and Restoration Plan for the Delta 2009.

Discover the Delta Foundation. 2010. Website used to identify recreational facilities in the Delta. http://www.discoverthedelta.org. Accessed by The Dangermond Group.

DOC (California Department of Conservation). 1984. Farmland Mapping and Monitoring Program 1984. Important Farmland designations for Alameda, Contra Costa, Solano, and Yolo counties. Site accessed July 22, 2010. ftp://ftp.consrv.ca.gov/pub/dlrp/fmmp/.

DOC (California Department of Conservation). 1988. Farmland Mapping and Monitoring Program 1988. Important Farmland designations for Sacramento County. Site accessed July 23, 2010. ftp://ftp.consrv.ca.gov/pub/dlrp/fmmp/.

DOC (California Department of Conservation). 1990. Farmland Mapping and Monitoring Program 1990. Important Farmland designations for San Joaquin County. Site accessed July 15, 2010. ftp://ftp.consrv.ca.gov/pub/dlrp/fmmp/.

DOC (California Department of Conservation). 2008. Farmland Mapping and Monitoring Program 2008. Important Farmland designations for Alameda, Contra Costa, Sacramento, San Joaquin, Solano, and Yolo counties. Site accessed October 8, 2009. ftp://ftp.consrv.ca.gov/pub/dlrp/fmmp/.

DOC (California Department of Conservation). 2009. Williamson Act designations for California. Site accessed August 20, 2010. ftp://ftp.consrv.ca.gov/pub/Dlrp/WA/Map%20and%20PDF/CALIFORNIA%20WILLIAMSON%20ACT/Total%20WA%20GIS%20to%202009/.

DPC (Delta Protection Commission). 2006. GIS layer prepared by The Dangermond Group identifying recreation facilities in the Delta for the Delta Recreation Strategy Plan. Delivered from Doug Gardner, The Dangermond Group, to Eryn Pimentel, AECOM on March 7, 2011.

DPC (Delta Protection Commission). 2010. *Land Use and Resource Management Plan for the Primary Zone of the Delta*. Adopted February 25, 2010.

DPC (Delta Protection Commission). 2011. *Feasibility Study for a Sacramento-San Joaquin Delta National Heritage Area*. Public Review Draft. October.

DPC (Delta Protection Commission). 2012a. *Proposal to Protect, Enhance, and Sustain the Unique Cultural, Historical, Recreational, Agricultural, and Economic Values of the Sacramento-San Joaquin Delta as an Evolving Place*. January 26.

DPC (Delta Protection Commission). 2012b. *Economic Sustainability Plan for the Sacramento-San Joaquin Delta*. Public Draft. October 10.

DWR (California Department of Water Resources). 2008. Topical Area: Economic Consequences. Technical Memorandum: Delta Risk Management Strategy Phase 1. Final. May.

DWR (California Department of Water Resources). 2009. *California Water Plan Update 2009.* Sacramento, CA.

Federal Emergency Management Agency (FEMA). 2008. *Flood Plain Management Bulletin – Historic Structures*. FEMA P-467-2.

Fredrickson, D. A. 1974. Cultural diversity in early central California: a view from the north Coast Ranges. *Journal of California Anthropology* 1(1):41-53.

Johnson, P. J. 1978. Patwin. *Handbook of North American Indians*. Volume 8: California. Edited by R. F. Heizer, 350-360. Washington, D.C.: Smithsonian Institution.

Kroeber, A. L. 1925. Handbook of the Indians of California. *Bureau of American Ethnology Bulletin 78*.

Kroeber, A. L. 1932. The Patwin and their neighbors. *University of California Publications in American Archaeology and Ethnology* 29(4):253-423.

Levy, R. 1978. Eastern Miwok. *Handbook of North American Indians*. Volume 8: California. Edited by R. F. Heizer, 398-413. Washington, D.C.: Smithsonian Institution.

Lund, J., E. Hanak, W. Fleenor, R. Howitt, J. Mount, and P. Moyle. 2007. *Envisioning Futures for the Sacramento-San Joaquin Delta*. Public Policy Institute of California. San Francisco, CA.

Miller, Robin. 2008. *Subsidence Reversal in a Re-established Wetland in the Sacramento-San Joaquin Delta, California, USA*. U.S. Geological Survey.

Moratto, M. J. 1984. *California Archaeology*. San Francisco: Academic Press.

Mountain House Community Services District. 2008. Mountain House Zoning map. September 18, 2008. Site accessed July 27, 2011. http://www.ci.mountainhouse.ca.us/master-plan.asp.

Probolsky Research. 2012. *California Statewide Voter Survey: Report on Results*. January 27, 2012.

Reclamation District 2093. 2009. *Liberty Island Conservation Bank Initial Study/Mitigated Negative Declaration*. April.

SACOG (Sacramento Area Council of Governments). 2009. GIS layer for Spheres of Influence in SACOG region. December. Site accessed January 28, 2011. http://sacog.org/mapping/clearinghouse/Mapping Center.

SACOG (Sacramento Area Council of Governments). 2011. *Sacramento Region Rural-Urban Connections Strategy*. May.

Sacramento County. 2011. General Plan land use designations in GIS format. Site accessed 2012. http://www.sacgis.org/GISDataPub/Data/.

Sacramento County. 2012. Letter from Sacramento County to the Delta Stewardship Council, Re: Revised Maps of the Unincorporated Delta Communities. November 20.

Sacramento County. 2013. Sacramento County Online Map, Sacramento County, California. Site accessed March 10, 2013. http://generalmap.gis.saccounty.net/JSViewer/county_portal.aspx

San Joaquin County. 2008a. City of Lathrop SOI map. March 4. Site accessed February 3, 2011. http://www.sjgov.org/lafco/SOI%20Maps/Lathrop_Sphere_new%202008.pdf.

San Joaquin County. 2008b. City of Manteca SOI map. October 29. Site accessed February 3, 2011. http://www.co.san-joaquin.ca.us/lafco/Manteca%20MSR/Manteca_Sphere.pdf.

Solano County. 2008a. GIS layer for City Spheres of Influence in Solano County. May. Site accessed August 10, 2011. http://regis.solanocounty.com/data.html.

Solano County. 2008b. General Plan land use designations provided in GIS format. Obtained 2009.

Stockton Record. 2012. Poll finds few know about Sacramento-San Joaquin Delta. February 5. http://www.modbee.com/2012/02/05/2057167/poll-finds-few-know-anything-about.html.

Suddeth, R., J. Mount, and J. Lund. 2010. Levee decisions and sustainability for the Sacramento-San Joaquin Delta. *San Francisco Estuary and Watershed Science* 9(2).

Sumner, D., and J. Rosen-Molina. 2011. *Evaluations of Policy Alternatives to Benefit Agriculture in the Sacramento-San Joaquin Delta of California*. Developed by the University of California Agricultural Issues Center for the California Department of Food and Agriculture. February.

Trott, Ken. 2007. Context Memorandum: Agriculture in the Delta Iteration 2. August 10, 2007. Site accessed November 11, 2010. http://deltavision.ca.gov/context_memos/Agriculture/Agriculture_Iteration2.pdf.

University of California Archaeological Survey. 1956. No 35, *Papers of California Archaeology* 44-46.

Wallace, W. J. 1978. Northern Valley Yokuts. *Handbook of North American Indians*. Volume 8: California. Edited by R. F. Heizer, 462-476. Washington, D.C.: Smithsonian Institution.

Wilson, N. L., and A. H. Towne. 1978. Nisenan. *Handbook of North American Indians*. Volume 8: California. Edited by R. F. Heizer, 387-397. Washington, D.C.: Smithsonian Institution.

Yolo County. 2010a. General Plan land use designations in GIS format. Site accessed 2010. http://www.yolocounty.org/Index.aspx?page=823.

Yolo County. 2010b. Yolo County General Plan 2030 layer provided in GIS format. Delivered via file transfer protocol from Marcus Neuvert, GIS Specialist, Yolo County DITT, to Dillon Cowan, Staff Engineer, CH2M HILL, Inc., on July 1.

Photo Credits

Chapter divider *(clockwise from top left)***:** Chris Austin, California Department of Water Resources, Chris Austin, and California Department of Water Resources

Page 173: California Department of Water Resources

Page 179: California Department of Water Resources

CHAPTER 6

Improve Water Quality to Protect Human Health and the Environment

ABOUT THIS CHAPTER

This chapter discusses the trade-offs and conflicts inherent in managing water quality for multiple objectives. It recommends strategies to make balanced improvements primarily through the prioritization of projects and programs. It also provides support to related information in Chapters 3, 4, and 5.

Other State of California (State) agencies have broad authority to protect and regulate water quality. This chapter sets forth priority Sacramento-San Joaquin Delta (Delta)-specific recommendations for those agencies and focuses on four core strategies where best available science shows the need for improved water quality to achieve the coequal goals:

- Require Delta-specific water quality protection
- Protect beneficial uses by managing salinity
- Improve drinking water quality
- Improve environmental water quality

These core strategies form the basis of the 12 recommendations found at the end of this chapter. These major aspects are critical to protecting human health and improving the environment. Salinity is discussed in a separate section because of its importance as a defining characteristic of the estuary and its implications to ecosystem health, its linkage to water project operations, and its historical importance in the Delta.

RELEVANT LEGISLATION

The protection and improvement of water quality is inherent to meeting the coequal goals of the State. Water quality plays a critical role in the achievement of a more reliable water supply and protection, restoration, and enhancement of the Delta ecosystem. Water quality also contributes to the values of the Delta as an evolving place. The Sacramento-San Joaquin Delta Reform Act of 2009 calls for improving water quality as follows:

> *85020 The policy of the State of California is to achieve the following objectives that the Legislature declares are inherent in the coequal goals for management of the Delta:...(e) Improve water quality to protect human health and the environment consistent with achieving water quality objectives in the Delta.*

> *85022(d) The fundamental goals for managing land use in the Delta are to do all of the following: ... (6) Improve water quality to protect human health and the environment consistent with achieving water quality objectives in the Delta.*

> *85302(d) The Delta Plan shall include measures to promote a more reliable water supply that address all of the following: ... (3) Improving water quality to protect human health and the environment.*

> *85302(e) The following subgoals and strategies for restoring a healthy ecosystem shall be included in the Delta Plan... (5) Improve water quality to meet drinking water, agriculture, and ecosystem long-term goals.*

This page intentionally left blank.

CHAPTER 6

Improve Water Quality to Protect Human Health and the Environment

The Delta Reform Act acknowledges water quality as an important element of a reliable water supply and directs the Delta Stewardship Council (Council) to improve water quality to protect human health and the environment. In general, water quality is an abstract concept unless it is discussed relative to protection of the beneficial uses of that water. The Delta Reform Act highlights drinking water, agriculture, and ecosystem goals as important beneficial uses for the purpose of the Delta Plan. The Council's role with respect to water quality is to ensure that the policies and recommendations in the Delta Plan balance the protection of myriad—and sometimes competing—beneficial uses of water.

In California, the entities primarily responsible for managing water quality in the state are the nine regional water quality control boards (RWQCBs) and the State Water Resources Control Board (SWRCB). The RWQCBs are responsible for water quality planning, permitting and enforcement, and financial assistance, when funds are available. The SWRCB is responsible for statewide plans, permits, and policies, and serves as a review body for RWQCB decisions. The SWRCB also has the important and challenging task of administering the State's complex water rights system of permits and licenses. As part of these duties, the SWRCB sets water quality objectives for major waterways, including the tributaries of the Delta, as described in Chapter 4. The Central Valley RWQCB is the regional board with primary jurisdiction in the Delta and Delta watershed.

Water quality in the Delta is influenced by many factors. Seasonal rainfall, snow runoff, and reservoir releases flow in from several rivers and streams, primarily the Sacramento and the San Joaquin rivers. During very high flows, some of this water flows across floodplains before it enters the Delta. Tides can bring saline waters into the Delta from the San Francisco Bay. There are also discharges from cities, industries, and agricultural lands. As all of these flows enter the Delta, they bring with them a variety of contaminants. Additionally, water is diverted from the Delta, either for use within the Delta or for use in Central and Southern California and other service areas. The timing and physical qualities of these flows into and out of the Delta affect the water quality needed to support the beneficial uses of Delta waters.

In achieving the coequal goals, the Council envisions a Delta where improved water quality supports a healthy ecosystem and the multiple beneficial uses of water, including municipal supply and recreational uses such as fishing and swimming. To support a more resilient and healthy Delta ecosystem, salinity patterns should be consistent with more natural flow patterns with inflows of high-quality water. Nutrient concentrations should support diverse and productive aquatic food webs, and should not cause excessive growth of nuisance aquatic plants or blooms of harmful algae. Physical attributes of the aquatic environment, such as dissolved oxygen (DO) concentrations, temperature ranges, and turbidity levels, should support the needs of native species. At all times, the Delta should be free of harmful concentrations of toxic substances. Discharges of treated wastewater, urban runoff, or agricultural return flows should be regulated so that they do not have a negative effect on the Delta. High water quality is imperative to the coequal goals and crucial for protecting the beneficial uses of Delta water, successful restoration of aquatic habitats, and sustenance of native plants and animals.

Beneficial uses of Delta waters involve trade-offs that are important to recognize and address when establishing water quality goals. These trade-offs emerge in cases where acceptable or even ideal water quality for one use may have unintended or adverse effects on another use. For example, variable salinity levels are beneficial for many native species in the Delta, but can be problematic for agricultural or municipal uses. Bromide salts, one component of salinity, can result in cancer-causing disinfection byproducts with some water treatment methodologies. Similarly, organic carbon in drinking water sources can contribute to harmful disinfection byproduct formation (Leenheer and Croue 2003). However, for ecosystem purposes, organic carbon is beneficial and is increased by wetland creation. Also, wetland creation can result in increased methylation of mercury, resulting in bioaccumulation of mercury in fish species, a threat to human health when these fish are consumed. Water quality is strongly connected to water supply, as reservoir releases to control salinity can reduce the availability of fresh water at times of the year when it is needed most. These and other issues affecting water quality policy are discussed in this chapter.

Beneficial Uses of Water in and from the Delta

A goal of the Delta Plan is to maintain water quality at a level that supports and enhances designated beneficial uses. Table 6-1 lists the beneficial uses for water in the Delta as specified in the SWRCB's 2006 *Water Quality Control Plan for the San Francisco Bay/Sacramento–San Joaquin Delta Estuary* (Bay-Delta Plan).

The most important part of any water quality discussion is identifying the existing and potential uses of the water in question. These uses drive the level of water quality that must be attained, and what requirements and limitations must be placed on dischargers and diverters of that water to protect those uses. Specific discharge limitations are based on adopted science-based objectives necessary to protect associated beneficial uses. These limitations are then included in discharge permits.

Factors Influencing Water Quality in the Delta

This section provides an overview of factors that influence water quality in the Delta and existing water quality regulations. Water quality in the Delta is influenced by factors such as:

- Freshwater inflows and outflows
- In-Delta land use
- Dredging
- The Delta levee system
- Tides
- Point source inputs of pollutants
- Nonpoint source inputs of pollutants
- In-Delta water use
- Export diversions and operations

Delta Water Beneficial Uses

TABLE 6-1

Beneficial Use	Description
Municipal and Domestic Supply	Uses of water for community, military, or individual water supply systems including, but not limited to, drinking water supply.
Industrial Service Supply	Uses of water for industrial activities that do not depend primarily on water quality including, but not limited to, mining cooling water supply, hydraulic conveyance, gravel washing, fire protection, and oil well repressurization.
Industrial Process Supply	Uses of water for industrial activities that depend primarily on water quality.
Agricultural Supply	Uses of water for farming, horticulture, or ranching including, but not limited to, irrigation, stock watering, or support of vegetation for range grazing.
Groundwater Recharge	Uses of water for natural or artificial recharge of groundwater for purposes of future extraction, maintenance of water quality, or halting of saltwater intrusion into freshwater aquifers.
Navigation	Uses of water for shipping, travel, or other transportation by private, military, or commercial vessels.
Water Contact Recreation	Uses of water for recreational activities involving body contact with water, where ingestion of water is reasonably possible. These include, but are not limited to, swimming, wading, water skiing, skin and scuba diving, surfing, white-water activities, fishing, or use of natural hot springs.
Non-contact Water Recreation	Uses of water for recreational activities involving proximity to water, but not normally involving body contact with water, where ingestion is reasonably possible. These include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tide pool and marine life study, hunting, sightseeing, or aesthetic enjoyment in conjunction with the above activities.
Shellfish Harvesting	Uses of water that support habitats suitable for the collection of filter-feeding shellfish (e.g., clams, oysters, and mussels) for human consumption, commercial, or sports purposes.
Commercial and Sport Fishing	Uses of water for commercial or recreational collection of fish, shellfish, or other organisms including, but not limited to, uses involving organisms intended for human consumption or bait purposes.
Warm Freshwater Habitat	Uses of water that support warmwater ecosystems including, but not limited to, preservation of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.
Cold Freshwater Habitat	Uses of water that support coldwater ecosystems including, but not limited to, preservation or enhancements of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.
Migration of Aquatic Organisms	Uses of water that support habitats necessary for migration or other temporary activities by aquatic organisms, such as anadromous fish.
Spawning, Reproduction, and/or Early Development	Uses of water that support high-quality aquatic habitats suitable for reproduction and early development of fish.
Estuarine Habitat	Uses of water that support estuarine ecosystems including, but not limited to, preservation or enhancement of estuarine habitats, vegetation, fish, shellfish, or wildlife (e.g., estuarine mammals, waterfowl, shorebirds).
Wildlife Habitat	Uses of water that support estuarine ecosystems including, but not limited to, preservation and enhancement of terrestrial habitats, vegetation, wildlife (e.g., mammals, birds, reptiles, amphibians, invertebrates), or wildlife water and food sources.
Rare, Threatened, or Endangered Species	Uses of water that support habitats necessary, at least in part, for the survival and successful maintenance of plant or animal species established under State or federal law as being rare, threatened, or endangered.

Source: SWRCB 2006

Generally, water quality is better in the northern Delta than in the central and southern Delta because higher-quality Sacramento River inflows are greater than inflows from the San Joaquin River, and the proportion of agricultural water use and drainage in the San Joaquin Valley is greater than in the Sacramento Valley. The SWRCB has listed Delta waterways (various streams, rivers, and sloughs in the Delta), the Carquinez Strait, and San Francisco Bay as having impaired water quality pursuant to the federal Clean Water Act (CWA) section 303(d) list[1] (SWRCB 2010). Pollutants of concern include insecticides, herbicides, mercury, selenium, nutrients, and legacy organic pollutants such as (DDT) and polychlorinated biphenyls (PCBs). Additional water quality issues in the Delta include temperature, salinity, turbidity, low DO, bromide, dissolved organic carbon, pathogens, and harmful algal blooms (HABs). Amounts of these constituents that are too high (or in some cases too low) can impair the ability of these waters to support beneficial uses, such as municipal water supply, recreational use, agricultural water supply, and habitat that supports healthy fish and wildlife populations. See Chapter 4 for additional discussion on how these water quality stressors can affect the Delta and its ecosystem.

Protecting Water Quality Is a Balancing Act

Water quality is central to the State's goals for the Delta – restoring the Delta ecosystem and providing for a more reliable water supply, while protecting and enhancing the Delta as a unique and evolving place. Conditions that affect water quality must be managed and balanced in a way that allows these goals to be met simultaneously. When one use is protected, steps must be taken to minimize impacts on other uses. The following examples of this interconnectedness illustrate the difficulty of the challenge at hand.

Water supply for agricultural, municipal, and industrial use requires control of chemical constituents such as salinity, and certain pollutants that could pose a threat to human health. Efforts to protect, enhance, and restore the Delta ecosystem, however, require the management of volume and timing of flows to provide beneficially variable salinity for certain species and sufficient fresh water for others. This management regime must also consider management of nutrients and suspended solids to ensure a viable food chain within the Delta.

Protecting the communities within the Delta and their water use involves many of these same salinity and pollutant controls that are important for any water supply, but water quality in the Delta must also support recreational uses such as swimming, fishing, and boating. Cumulative discharges of pollutants from Delta communities and from recreational craft can affect in-Delta uses. Sea level rise caused by climate change will affect in-Delta water use and the manner in which flows are managed to meet water quality demands. Levee construction and placement is important to guard against flooding that could threaten in-Delta and exported water supplies. In addition, levee construction can either disrupt ecosystem processes or help provide important habitat benefits, depending on the project's location and individual attributes.

Climate Change

Impacts on water quality from climate change are difficult to predict. However, a recent analysis by the U.S. Geological Survey (USGS) suggests that climate change poses a significant threat to water quality (Cloern et al. 2011). Increases in sea level would increase salinity intrusion into the Delta, threatening water quality for agricultural and municipal uses. Increased air and water temperatures would result in increased runoff amounts in winter, with less in spring and summer. Warmer water can directly affect the life cycle of many fish species and stimulate growth of nuisance aquatic plants or blooms of harmful algae, which can lead to

[1] The "303(d) list" is the list of impaired and threatened waters (stream/river segments, lakes) that states have identified as not meeting water quality standards and other requirements. Under section 303(d), the law requires that states establish priority rankings for waters on the list and develop total maximum daily loads (TMDLs) for these waters.

decreases in DO and increases in organic carbon. Increased runoff in the winter could result in more erosion and greater pulses of pollutants.

Existing Water Quality Regulations

Many different agencies have a role in the regulation of water quality in the Delta. The SWRCB and the RWQCBs have primary responsibility over discharges affecting beneficial uses of water in California with the oversight of the U.S. Environmental Protection Agency (USEPA). Drinking water supply is regulated by the California Department of Public Health, also with oversight by USEPA. Additionally, the California Department of Pesticide Regulation regulates the sale and use of pesticides, which affect water quality. (See sidebar, A Water Quality Success Story.)

A WATER QUALITY SUCCESS STORY

Widespread use of the organophosphorus pesticide diazinon in the Central Valley and episodes of aquatic toxicity caused the Central Valley RWQCB to add the Sacramento and Feather rivers to its list of impaired water bodies in 1994. A total maximum daily load for diazinon was adopted in 2003. Stakeholders also took action to implement a diazinon control strategy, and the USEPA and California Department of Pesticide Regulation took steps to restrict approved uses of diazinon. Grants from the USEPA, the former CALFED Bay-Delta Program, and other agencies provided funding support for control program implementation and research throughout the Central Valley region, including the San Joaquin River.

These water quality control efforts have helped to reduce levels of diazinon to the point that violations of water quality standards in the Sacramento and San Joaquin rivers are rare. Although pesticide pollution is still a problem in parts of some Central Valley streams and rivers, the experience with diazinon shows that programs to address these and other water quality problems can be effective (USEPA 2010).

DP-185

The RWQCBs develop water quality control plans (known as Basin Plans) that establish water quality standards and implementation plans for achieving standards for all surface water and groundwater in their respective regions. Water quality standards include identification of beneficial uses, numeric and narrative water quality objectives to protect those uses, and water quality control policies. The RWQCBs issue discharge permits and requirements that specify the amounts of pollutants that may be discharged based on these objectives. Although these permits are intended to ensure protection of these beneficial uses, some water bodies continue to exceed standards, and beneficial uses are not being protected. These impaired water bodies are identified and listed pursuant to federal CWA section 303(d).

Placement of a water body on the CWA 303(d) list initiates a process to develop a pollution limit, or total maximum daily load (TMDL), to address each pollutant causing the impairment. A TMDL defines how much of a pollutant a water body can tolerate and still meet water quality standards. The TMDL must account for all sources of a pollutant, including point sources and nonpoint sources (discharges from wastewater treatment facilities; runoff from urban areas, agricultural inputs, and streets or highways; "toxic hot spots"; and aerial deposition). In addition to accounting for past and current activities, TMDLs may also consider projected future population growth that could increase pollutant levels. The TMDL identifies allocations for point sources and for nonpoint sources, and includes a margin of safety to account for uncertainty. An implementation plan is developed that specifies a set of actions that must be carried out to ensure that the TMDL results in achievement of water quality standards. TMDLs are usually implemented through amendments to the appropriate Basin Plan, which, in turn, will result in changes to discharge permits as they are reissued. Once a TMDL is approved, it may be some time before the necessary studies are completed to set and apportion specific discharge limitations among all dischargers and potential dischargers.

The 2008-2010 Integrated Report (SWRCB 2010), which includes the 303(d) list, prioritizes TMDLs to be developed for each water body-pollutant combination on the CWA section 303(d) list, and establishes schedules for completion of the TMDLs. Approved TMDLs and TMDLs under development are listed in Table 6-2.

On February 10, 2011, the USEPA issued an Advanced Notice of Proposed Rulemaking (USEPA 2011) as part of an effort to assess the effectiveness of current water quality programs designed to protect aquatic species in the San Francisco Bay and the Delta (referred to here as the Bay-Delta). The document identified key water quality issues affecting Bay-Delta aquatic resources and summarized current research for each of these issues, including total ammonia, selenium, pesticides, emerging contaminants, and other parameters affecting estuarine habitat and the migratory corridors of anadromous fish. The notice was intended to solicit public comment on possible USEPA actions to address water quality conditions affecting the Bay-Delta. USEPA may make changes to programs in the Bay-Delta through a formal rulemaking process as a result of further evaluation and consideration of public comment. These changes could affect federal water quality programs administered by the State.

Water quality in the Delta is also regulated by the San Francisco Bay Conservation and Development Commission (BCDC), which has jurisdiction on all tidal areas of the Bay, including Suisun Bay and Suisun Marsh. BCDC policies regarding water quality are intended to prevent the release of pollution into Bay waters to the greatest extent feasible. The BCDC makes decisions regarding water quality impacts based on evaluation by and the advice of the San Francisco Bay RWQCB. The BCDC reviews State and federal actions, permits, projects, licenses, and grants affecting the Bay, including Suisun Marsh, pursuant to the federal Coastal Zone Management Act.

In the Delta and the Suisun Marsh, the Bay-Delta Plan establishes water quality objectives for which implementation is achieved through assigning responsibilities to water right holders and water users (SWRCB 2006). (See sidebar, Water Board Regulation and the Bay-Delta Plan.) This is because the parameters to be controlled are significantly affected by flows and diversions; these responsibilities were established in Water Rights Decision 1641 in 1999. The Bay-Delta Plan also provides protection for beneficial uses that require control of salinity and operations of the various water projects in the Delta, including the State Water Project (SWP) and Central Valley Project (CVP) (SWRCB 2006).

TMDLs Approved and under Development in the Central Valley, Delta, and Suisun Bay

TABLE 6-2

Water Bodies	Pollutants	Status
American River	Mercury	Under Development
Cache Creek, Bear Creek, Harley Gulch	Mercury	Approved
Central Valley	Organochlorine Pesticides	Under Development
Central Valley	Pesticides	Under Development
Clear Lake	Mercury	Approved
Clear Lake	Nutrients	Approved
Grasslands	Selenium	Approved
North San Francisco Bay (includes Suisun Bay)	Selenium	Under Development
Sacramento and Feather Rivers	Diazinon	Approved
Sacramento County Urban Creeks	Diazinon and Chlorpyrifos	Approved
Sacramento-San Joaquin River Delta	Diazinon and Chlorpyrifos	Approved
Sacramento-San Joaquin River Delta	Mercury	Approved
Salt Slough	Selenium	Approved
San Francisco Bay (includes Suisun Bay)	Mercury	Approved
San Francisco Bay (includes Suisun Bay)	PCBs	Approved
San Francisco Bay Area Urban Creeks	Diazinon/Pesticide Toxicity	Approved
San Joaquin River	Salt and Boron	Approved
San Joaquin River	Diazinon and Chlorpyrifos	Approved
San Joaquin River	Selenium	Approved
Stockton Deep Water Ship Channel (Phase 1)	Dissolved Oxygen	Approved
Stockton Deep Water Ship Channel (Phase 2)	Dissolved Oxygen	Under Development
Stockton Urban Sloughs	Dissolved Oxygen	Under Development
Stockton Urban Water Bodies	Pathogens	Approved
Suisun Marsh	Dissolved Oxygen	Under Development
Suisun Marsh	Mercury	Under Development
Upper Sacramento River	Cadmium, Copper, and Zinc	Approved

Sources: Central Valley RWQCB 2011; San Francisco Bay RWQCB 2011a

The SWRCB and RWQCBs are the regulatory agencies with statutory authority to adopt water quality control plans, including regulating waters for which water quality standards are required by the federal CWA (Water Code sections 13170 and 13240). The Council recognizes the SWRCB's role and authority in regulating water quality, and supports and encourages the timely development and enforcement of programs (for example, water quality objectives and waste discharge requirements (WDRs), TMDLs, and National Pollutant Discharge Elimination System [NPDES] permits) to reduce pollutant loads that are causing water quality impairments in the Delta. The Council also supports and encourages the completion of the elements of the SWRCB's 2010 *Update to Strategic Plan 2008-2012* (June 2010) and the *Strategic Workplan for Activities in the San Francisco Bay/Sacramento–San Joaquin River Delta Estuary* (July 2008) prepared by the SWRCB, Central Valley RWQCB, and San Francisco Bay RWQCB.

WATER BOARD REGULATION AND THE BAY-DELTA PLAN

Water Quality Criteria, Objectives, and Standards. The SWRCB and RWQCBs have primary responsibility for the regulation of discharges and control of pollutants that affect California's surface and groundwater resources.

The water boards do this by using scientific studies and information to first determine the water quality *criteria* that are needed for specific beneficial uses of that water. Examples of beneficial uses include drinking water use, agricultural use, recreation, and others listed in the Bay-Delta Plan. The water quality criteria are then used to develop water quality objectives.

Water quality *objectives* account for additional information such as economic impacts, effects on other uses, available technology, and similar factors. Water quality objectives are considered equivalent to water quality *standards* required by the USEPA. The RWQCBs adopt water quality control plans that contain these objectives; they identify specific beneficial uses of each water body covered by that plan and specific water quality objectives to protect those uses. These plans are then used to issue general or site-specific discharge permits with specific pollutant discharge limitations.

Section 303(d) of the federal CWA requires that California create a listing of impaired water bodies that are not meeting water quality standards. Water bodies on this 303(d) list require development of a TMDL, which establishes a limitation on the amount of pollution that water body can be exposed to without adversely affecting its beneficial uses. This TMDL allocates proportions of the total limitation among dischargers to the impaired surface water. TMDLs typically result in changes to water quality control plans, so that existing and future permits contain pollutant limits or other provisions necessary to ensure that the water quality standards are met.

Flow Objectives. The SWRCB is responsible for administering and overseeing the right to take and use water in California. Where storage, transport, diversion, and use of water threaten to adversely affect water quality and beneficial uses, the SWRCB may adopt plans that set objectives for water quality and flow where necessary to protect beneficial uses. As a special kind of water quality objective, *flow objectives* are developed on the basis of scientifically developed information and account for other factors, such as economic impacts, physical constraints, and effects on other uses such as water supply and agricultural use.

The Bay-Delta Plan. In the case of the Delta, the SWRCB has adopted the Bay-Delta Plan. This plan contains water quality objectives, including flow objectives. The Delta Reform Act required that certain flow criteria be developed, which the SWRCB completed in 2010.

In early 2012, the SWRCB officially launched the comprehensive review of the Bay-Delta Plan. The water quality control planning phase of this review will include review of potential modifications to current objectives included in the Bay-Delta Plan, the potential establishment of new objectives, and modifications to the program of implementation for those objectives. It will also include potential changes to the monitoring and special studies program included in the Bay-Delta Plan. The water quality control planning process will not include amendments to water rights and other measures to implement a revised Bay-Delta Plan. A separate environmental impact report will be prepared for these actions. In addition, a separate substitute environmental document is being prepared to address updates to the water quality objectives for the protection of southern Delta agricultural beneficial uses, San Joaquin River flow objectives for the protection of fish and wildlife beneficial uses, and the program of implementation for those objectives.

DP-186

Salinity in the Delta

The Delta is an estuary, and like any estuary, fresh water from rivers and tributaries flows downstream where it mixes with salt water. The location, extent, and dynamics of the freshwater-saltwater interface are important drivers of many estuarine (ecological) processes and important considerations in water management for human uses. The geographic extent of water of the correct salinity is important to many estuarine species as it is an important characteristic of their habitat. Crops vary in their tolerance of salt content in water used for irrigation, and salinity can reduce yields of sensitive crops at relatively low levels. Salt in municipal water supplies increases corrosion of pipes and appliances, can affect taste, and can contribute to the formation of disinfection byproducts that are harmful to human health. The management-intensive regulation of salinity in the Delta for multiple benefits is another example of the highly altered system the Delta has become. This section provides a summary of the history of Delta salinity problems and the effects of salinity on agricultural, municipal, and industrial water use.

History and Causes of Delta Salinity Problems

The location of the freshwater-saltwater interface in the estuary shifts with the seasons and the tides and from year to year depending on the amount of precipitation, water diversions, and Delta outflow (Kimmerer 2004; Malamud-Roam et al. 2007; Stahle et al. 2011). The location, extent, and dynamics of this freshwater-saltwater gradient have changed over the past 150 years because of landscape modification, water management and flood management infrastructure such as dams and conveyance facilities, channel dredging, and climate change.

Figure 6-1 is a representation of salinity over a range of concentrations relevant to suitability for water supply. It shows the salinity gradient in the western Delta under high and low outflow conditions. Changes in seasonal inflow to the Delta caused by upstream diversions, storage of water behind the State and federal water project dams, and operation of the State and federal Delta pumps have generally shifted the salinity gradient upstream and have changed seasonal and interannual salinity patterns. Even with these measurable shifts in salinity caused by diversion, storage, and conveyance of water, a primary driver of seasonal and annual salinity variability in the western Delta and Suisun Marsh continues to be the amount of precipitation in the watershed (Enright and Culberson 2010).

The examination of tree rings throughout the mountains of California provides a good indicator of precipitation over the last 650 years, but tree rings alone cannot accurately reproduce the details of Delta salinity over this period (Stahle et al. 2011). However, strong evidence indicates that the western Delta was a freshwater ecosystem for 2,500 years before human modification in the nineteenth and twentieth centuries (Malamud-Roam and Ingram 2004). Channel dredging, significant reductions in tidal marsh area, and levee construction have changed Delta salinity by increasing the strength of tides in the Delta, increasing connections between channels, and reducing the moderating effects of wetlands and floodplains on outflow. Consequently, simply allowing more variability in Delta outflow will not produce the same salinity patterns that existed before development.

Although sea water is the primary source of salinity in the western Delta and Suisun Marsh, it is not the only source. Agricultural drainage is another significant source of salinity, particularly in the San Joaquin Valley. Municipal and industrial discharges also can locally increase salinity, although such salinity increases are generally small compared to increases from brackish water inputs. All surface waters and groundwaters contain some amount of salt, and this salt is concentrated with use through evaporation and transpiration of water by plants (Central Valley Drinking Water Policy Workgroup 2007). The remaining water in drainage, agricultural return flows, or percolated groundwater has a higher salt concentration than the supply water. This normal increase in salinity with water use is exacerbated in some parts

Salinity in the Delta Varies by Inflow Volumes

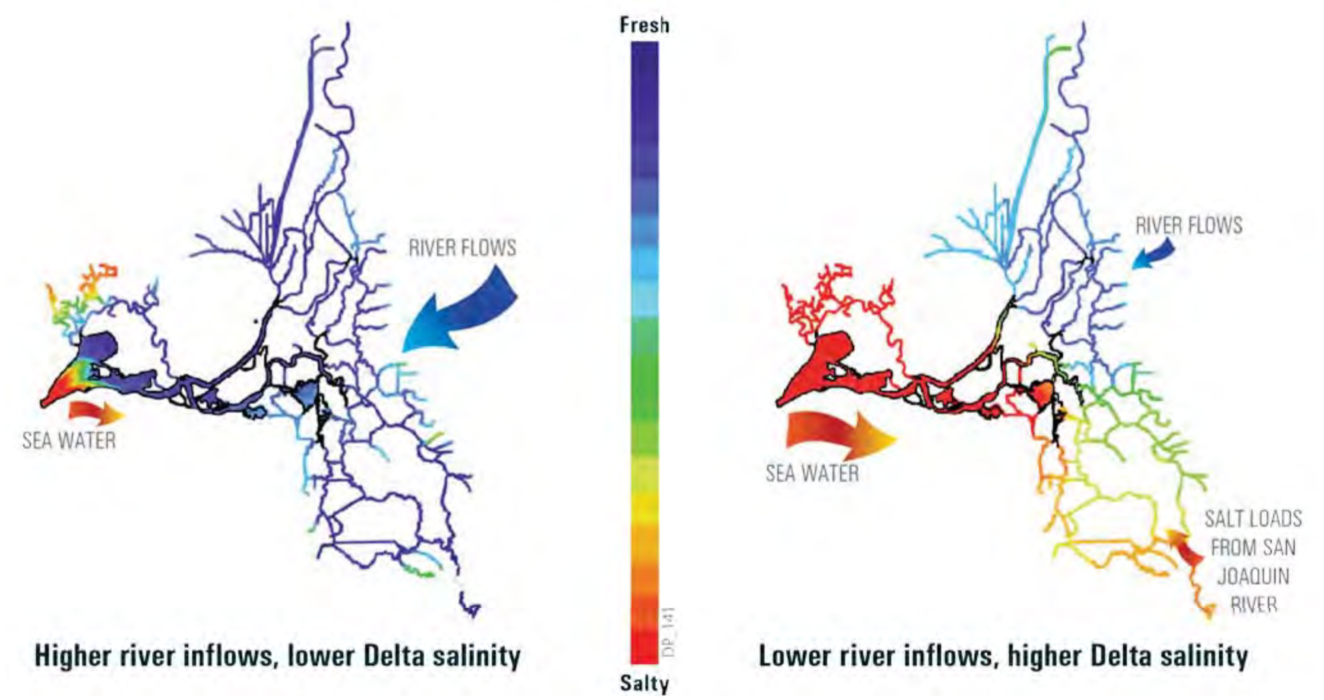


Figure 6-1

Delta salinity varies with inflow and outflow. Very high flows (left) push fresh water well into Suisun Bay and produce low-salinity conditions throughout the Delta. During very low flow periods (right), sea water can be seen pushing into the interior Delta from Suisun Bay with high salinity also entering from the San Joaquin River in the southeastern Delta.

Source: Central Valley Drinking Water Policy Workgroup 2007; images created by Resource Management Associates

of the San Joaquin Valley by naturally occurring salts in soils and a Delta water supply that already includes salt. Some of the salt load in the San Joaquin Valley accumulates in groundwater, affecting a variety of uses. Another manifestation of the salt problem is elevated salinity in the San Joaquin River at the point where it enters the Delta; this level is much higher than in the Sacramento River and marginally meets applicable water quality standards for much of the year. At times, salinity from sea water mixing into the western Delta and salinity from the San Joaquin River creates a Delta with a "freshwater corridor" leading from the Sacramento River to the State and federal water export pumps in the south Delta.

Salinity in the Delta Ecosystem

The role of water quality characteristics in ecosystem function, including salinity, temperature, turbidity, and DO, is discussed in detail in Chapter 4. Salinity is a defining characteristic of habitat for estuarine organisms and perhaps the most important water quality characteristic affecting municipal, industrial, and agricultural water use. However, salinity patterns that benefit native species are sometimes in conflict with human uses of water.

The salinity tolerances and preferences of fish vary by species. Delta smelt spawn in fresh water, but juveniles and adults generally show a preference for salinity in the range of 0.5 to 5 parts per thousand (ppt). Adult longfin smelt tolerate a much wider range of salinity and thrive in salinities greater than 5 ppt. Splittail do well in a wide range of salinities from fresh water up to 18 ppt (Moyle 2002). Largemouth bass and bluegill, introduced species, prefer fresh water and are rarely found at salinities greater than 1 to 2 ppt. The location, extent, and dynamics of the freshwater-saltwater interface in the Bay-Delta is an important factor in the distribution and abundance of many fish, invertebrate, and plant species, and is largely determined by the amount of fresh water flowing from the Delta west into Suisun Bay.

The interface between fresh water and salt water is a critical region of the estuary for many native fish and other organisms. Although there is no broadly accepted definition, the low salinity zone (LSZ) of the estuary is generally considered to be the region with salinity ranging from fresh water up to about 5 ppt, about one-seventh the salinity of sea water. The part of the salinity gradient centered on 2 ppt is considered to be of particular importance because it is hypothesized to be an area where suspended particulate matter and organisms accumulate. The location in the Bay-Delta where the tidally averaged salinity at 1 meter from the bottom is 2 ppt is known as X2 (measured as distance in kilometers from the Golden Gate Bridge) and serves as a water quality objective to regulate Delta outflow. The endangered Delta smelt show a preference for the LSZ. Their distribution during most of the year is centered near X2 (Nobriga et al. 2008). The position of X2 is also correlated with the abundance of several estuarine fish and invertebrates such as the bay shrimp and longfin smelt. That is, higher outflows (X2 located closer to the Golden Gate Bridge) are correlated with greater abundance of longfin smelt and bay shrimp (Kimmerer 2004). However, the processes linking greater Delta outflow with the abundance of estuarine species in the Bay-Delta system are not clearly understood, and continue to be studied and debated.

One proposed mechanism for the benefits of X2 as a regulatory marker for Delta smelt and other pelagic species is its relationship to the extent of low-salinity habitat. Lower values of X2 place it in the vicinity of Grizzly and Suisun bays, which results in a much larger area of low-salinity habitat than when X2 is located upstream of the confluence of the Sacramento and San Joaquin rivers. One of the potential negative effects of climate change will be a reduction in the availability of suitable low-salinity habitat for Delta smelt. The combined effects of sea level rise and changes in other aspects of estuarine habitat caused by climate change and increased water diversions are likely to pose a significant threat to the future survival of Delta smelt (Feyrer et al. 2011). Additional information on the relationship between flows in the Delta, the low-salinity zone, and implications for ecosystem health is included in Chapter 4.

Effects of Salinity on Agricultural Water Use

As noted in Chapter 5, agricultural use of water in the Delta is a significant factor in the health of the Delta's regional economy. The effect of salinity on agricultural water use varies by crop, soil type, and other factors (Hoffman 2010). The existing water quality objective, designed to protect the most sensitive crops, is set by the SWRCB at 700 microsiemens per centimeter (μS/cm) during the irrigation season and 1,000 μS/cm for the remainder of the year in southern Delta channels. At 700 μS/cm, water is relatively fresh, approximately equivalent to a salinity of 0.37 ppt (about 1 percent). The SWRCB is reviewing this objective based on the most recent information about the impacts of salinity on typical Delta crops. Salts from upstream and in-Delta agricultural drainage and from seawater intrusion from the Bay can affect agricultural water use in the Delta. Poor flow circulation in some parts of the Delta resulting from water diversions and historical channelization can exacerbate salinity problems.

Water quality to protect agricultural water use in the southern Delta is controlled through a combination of San Joaquin River inflow, export pumping, and Delta outflow changes. When salinity threatens to exceed water quality objectives for the San Joaquin River near Vernalis, additional high-quality water is released from New Melones Reservoir.

The effect of these releases is tempered by the installation and operation of flow barriers in the southern Delta to benefit agriculture. Salinity from seawater intrusion is reduced through a combination of reservoir releases, gate closures, and export pumping changes that, when necessary, control Delta outflow. Any significant changes to the way that water moves into or through the Delta, such as sea level rise, changed conveyance, changed inflow, or changed outflow, will change salinity patterns in the Delta.

Water quality at the SWP and CVP export pumps in the southern Delta, while usually meeting all applicable standards for municipal and agricultural use, is significantly higher in salinity than Sacramento River inflow to the Delta. Allowing salinity to vary in a way that might benefit native species could affect agricultural and municipal uses of Delta water.

Effects of Salinity on Municipal and Industrial Water Uses

Salinity contamination of municipal water supplies, as described in the following section on drinking water quality, can make water unpalatable, contributes to the formation of harmful disinfection byproducts, and increases corrosion of pipes and equipment. The existing objectives for protection of municipal and industrial beneficial uses in the southern Delta, expressed as limits on concentration of chloride, were developed to protect former industrial uses, but have been retained because they also protect drinking water quality. Secondary standards (standards that apply to aesthetic properties) for drinking water supplies also apply to water exported from the Delta by the CVP and SWP.

Under the current salinity regulations and operations practices for Delta water, municipal and industrial water supplies generally meet all salinity objectives. However, sea level rise, Delta levee failures, and increasing salt from upstream all threaten Delta municipal and industrial water supplies. Removing salts from water supplies is technically possible, although difficult and expensive; and disposing of the concentrated salt waste stream remains a key challenge.

Increased salinity further affects the reliability of municipal and industrial water supplies by reducing opportunities for water reuse and recycling (Healey et al. 2008), in turn potentially increasing reliance on imported surface water. Moving Delta intakes upstream, away from the influence of seawater intrusion and San Joaquin River inflow, could substantially reduce these water supply threats and is the subject of analysis under the current Bay Delta Conservation Plan process.

The salinity regime in the Delta is driven by natural flows, water management, and human land and water uses in the Delta and its watershed. Achieving the coequal goals will require updated comprehensive flow objectives and water quality control programs for salinity that balance ecosystem and water supply needs. The SWRCB must pay significant attention to the examination and resolution of these water quality issues in its development of new Delta flow requirements and as new plans for Delta conveyance are developed.

Drinking Water Quality

Water moving through the Delta contributes some part of the drinking water supplies for more than 25 million Californians. It is also used extensively for body-contact recreation such as swimming and water skiing. At the current locations where Delta water is diverted for municipal use, the water sometimes contains relatively high concentrations of bromide, organic carbon, nutrients, and dissolved solids (salinity). These drinking water constituents of concern are not directly harmful in drinking water, but they lead to formation of harmful chemicals during drinking water treatment, or contribute to taste, odor, or other municipal water supply problems. Sources of these drinking water constituents of concern include natural processes, such as tidal mixing of sea water into the Delta, and the flux of water and organic matter from wetlands, as well as urban runoff, agricultural runoff, and municipal wastewater discharge. Pathogenic (infectious) protozoa, bacteria, and viruses are also present in Delta waters and are a disease risk for both drinking water and body-contact recreation.

The future of water quality is a major concern for municipalities using Delta water. Current water quality regulations and policies for surface waters do not directly apply to many of the drinking water quality constituents of concern. Sea level rise, levee failure, salinity variability, agricultural water use, and increased urban runoff due to population growth in the watershed all pose a threat to drinking water quality. Clear policies regarding the protection of water quality relevant to the drinking water quality constituents of concern are needed to prevent such degradation. The Central Valley RWQCB is developing a drinking water policy that is, in part, intended to prevent the degradation of high-quality drinking water sources (Central Valley RWQCB 2010).

Disinfection Byproducts

Treatment of public water supplies is necessary to prevent disease caused by pathogenic organisms. However, bromide and organic carbon in municipal water supplies contribute to the formation of harmful disinfection byproducts when water is treated for domestic use (Healey et al. 2008, AWWA 2011). (See sidebar, Disinfection Byproducts.) The disinfection byproducts of primary concern in tap water, such as trihalomethanes (THMs), haloacetic acids, and bromates, are carcinogens subject to stringent public health standards. Treatment of water from the Delta is particularly challenging because it can contain elevated levels of both bromide and organic carbon (DWR 2007). Changes to drinking water treatment processes to reduce the amounts of disinfection byproducts in tap water are technologically challenging and can significantly increase the cost of drinking water treatment (Chen et al. 2010).

Organic carbon (total or dissolved) is an aggregate measure of the amount of a wide variety of organic compounds in water. In fresh water, these compounds typically come largely from decaying plant material. Along with bromide, elevated concentrations of organic carbon contribute to formation of disinfection byproducts. The amount of disinfection byproduct varies with the type and source of organic carbon, but total organic carbon concentration is nearly always correlated with disinfection byproduct formation. Large-scale restoration of wetlands could increase the amount of disinfection byproducts formed in Delta

DISINFECTION BYPRODUCTS

Disinfection byproducts are formed when disinfectants used in water treatment plants react with bromide and/or natural organic matter (decaying vegetation) present in the source water. Different disinfectants produce different types or amounts of disinfection byproducts. Disinfection byproducts identified in drinking water include THMs, haloacetic acids, and bromates. The USEPA has established regulations for these contaminants and set the maximum contaminant levels (MCLs) to prevent health effects (40 *Code of Federal Regulations* Part 141).

Trihalomethanes (THM) are a group of four chemicals formed along with other disinfection byproducts when chlorine or other disinfectants used to control microbial contaminants in drinking water react with naturally occurring organic and inorganic matter in water. The THMs are chloroform, bromodichloromethane, dibromochloromethane, and bromoform. THM violations are the primary difficulty for drinking water systems that use water from the Delta, especially the smaller systems. Some people who drink water containing total THMs in excess of the MCL over many years could experience liver, kidney, or central nervous system problems and increased risk of cancer.

Haloacetic acids are a group of chemicals formed along with other disinfection byproducts when chlorine or other disinfectants used to control microbial contaminants in drinking water react with naturally occurring organic and inorganic matter in water. Haloacetic acids include monochloroacetic acid, dichloroacetic acid, trichloroacetic acid, monobromoacetic acid, and dibromoacetic acid. Some people who drink water containing haloacetic acids in excess of the MCL over many years may have an increased risk of cancer.

Bromate is a chemical formed when ozone used to disinfect drinking water reacts with bromide in source water. Bromate formation is a problem for drinking water systems that use ozone as the primary disinfectant. Bromate violations are uncommon, but are a concern during low-flow years when seawater intrusion causes bromide concentrations in Delta water to increase. Some people who drink water containing bromate in excess of the MCL over many years may have an increased risk of cancer.

DP-187

water used for municipal supplies due to an increased amount of total organic carbon and the greater disinfection byproduct formation potential of wetland-derived organic carbon (Kraus et al. 2008).

Salinity

Salinity, frequently measured as electrical conductivity or total dissolved solids, has several significant effects on the use of water for domestic uses. Salts make water unpalatable at relatively low concentrations, with 500 parts per million total dissolved solids set as the recommended maximum level in the California secondary drinking water standards (California Code of Regulations, Title 22, section 64449). Salinity also increases the cost of treatment and costs to the consumer due to corrosion and other factors (Howitt et al. 2009). One common component of sea water, bromide, is a disinfection byproduct precursor that forms THMs and haloacetic acids with chlorine or chloramine disinfection, and forms bromate with ozone disinfection.

Pathogens

Pathogenic organisms and pathogen indicators are found in most surface waters. Two common protozoan pathogens that cause gastroenteritis, *Giardia lamblia* and *Cryptosporidium parvum*, have been found in Delta waters (at generally low levels) with respect to drinking water sources or body-contact recreation (Tetra Tech 2007). Source waters that exceed drinking water regulatory thresholds for *Cryptosporidium* trigger additional pathogen removal requirements (USEPA 2004). Although available data do not demonstrate that such conditions currently exist at Delta municipal water supply intakes, future plans that move or create new water intakes could result in increased treatment costs. Pathogen indicators such as fecal coliforms or *E. coli* are frequently at levels of concern in urban stormwater runoff. Several urban creeks and Delta water bodies that receive urban runoff are listed as impaired due to the presence of these indicator bacteria.

Nutrients

In the Delta, drinking water supplies with excessive levels of nutrients are primarily of concern because they, along with other factors such as residence time and temperature, can stimulate algae growth in the Delta and in reservoirs (Tetra Tech 2006a, Izaguirre and Taylor 2007). Algal blooms in storage reservoirs can disrupt treatment processes, and cause taste and odor problems. Taste and odor complaints associated with Delta water supplies have been attributed to algae growth in reservoirs or in the Delta itself (DWR 2007).

Drinking Water Intakes

The quality of Delta water with respect to drinking water use varies considerably both geographically and over time. Average organic carbon and bromide concentrations are very low in the Sacramento River where it enters the Delta. San Joaquin River water is moderately high in bromide, salinity, and nutrients, and moderately high in organic carbon. Intakes in the west Delta can be strongly influenced by the estuarine salinity gradient. An intake for the City of Antioch is frequently out of use because of salinity intrusions. The North Bay Aqueduct intake on Barker Slough in the northwest Delta is strongly affected by the local watershed and has the highest average organic carbon concentrations of any Delta municipal water supply intake (Tetra Tech 2006b). In addition to the drinking water quality problems at the current North Bay Aqueduct intake location, the intake may also have a negative effect on the ecosystem because it is located in an area that is otherwise high-quality habitat for listed native fish species.

Groundwater Quality Concerns

The drinking water supply from groundwater for many communities in the Delta and areas served by water exported from the Delta is contaminated by nitrates and other pollutants, particularly in the San Joaquin Valley. Survey findings show that a high financial burden is borne by low-income households when it comes to nitrate-contaminated water

(Pacific Institute 2011). The high cost of accessing water from alternative sources, coupled with the low earnings of these households, often makes safe drinking water in these communities unaffordable (Pacific Institute 2011). Small community and private water systems throughout the Central Valley and in the Delta rely on groundwater as their primary source of drinking water. They are affected by groundwater contamination to a greater degree than larger public water systems because many are in areas that are vulnerable to contamination (SWRCB 2011). Their wells are often shallower than larger community systems, and they have limited resources to treat or respond to contaminated groundwater problems. The California Legislature explicitly recognized these issues when, in 2012, it enacted Assembly Bill 685, declaring the established State policy that "every human being has the right to safe, clean, affordable, and accessible water adequate for human consumption, cooking, and sanitary purposes" (Water Code section 106.3(a)). More information on groundwater and how it relates to the Delta can be found in Chapter 3.

Environmental Water Quality

The Delta ecosystem is affected by a variety of pollutants discharged into Delta and tributary waters. Pollutants of concern affecting Delta biological species and ecosystem processes include nutrients, pesticides, mercury, selenium, and other persistent bioaccumulative toxic substances. Newly identified pollutants of potential concern (often referred to as emerging contaminants) also need to be investigated.

Nutrients

Nutrients, and their potential benefits and problems, have become an increasingly important component in the discussion of water quality issues in the Delta. The role of nutrients and nutrient loading for the Delta and Suisun Marsh is a subject of debate. Plant nutrients of concern in water are primarily nitrogen and phosphorus compounds including ammonia, ammonium, nitrite, nitrate, and phosphate. Excessive amounts (over fertilization) or altered proportions of these nutrients in streams, rivers, lakes, estuaries, or the coastal ocean can have detrimental effects on ecosystems. Die-offs of algae that deplete oxygen and cause fish kills are a well-known example, but even less obvious effects of nutrients can have important impacts on aquatic ecosystems. Changes in the types of algae that form the base of the aquatic food web, including growth of toxic algae, have been linked to excessive amounts or altered ratios of plant nutrients. Recent and current research is reconsidering the role of nutrients for aquatic ecosystems of the Delta, as follows:

- **Ammonium.** Ammonium in Delta waters has been shown to affect ecosystem water quality. Dugdale et al. (2007) has determined that ammonium concentrations may be having a significant impact on phytoplankton composition and open-water food webs because of suppression of diatom blooms in the Bay-Delta. Ammonium concentrations in Suisun Bay and the Delta have been increasing, primarily due to point source discharge loading from wastewater treatment facilities. It is not known, however, how much this inhibition extends to freshwater algae in the Delta.
- **Nutrient ratios.** Ratios of nutrients in Delta waters are thought to be a primary driver in the composition of aquatic food webs in the Bay-Delta (Glibert et al. 2011). The effect of ammonium on food webs in the Delta remains an open question, and much active research and healthy scientific debate continue.

- **Harmful algal blooms.** HABs create a toxic environment for aquatic organisms and the organisms that eat them. The emergence of HABs over the past decade threatens environmental water quality. The shift toward greater abundance of cyanobacteria in the Delta includes known HABs such as *Microcystis aeruginosa*. *Microcystis aeruginosa* has become a common bloom-forming component of the phytoplankton of the Delta during the warm summer and early fall months (Lehman et al. 2005, 2008). Interactions between nutrients and HABs in the Delta warrant additional study and are currently being investigated.
- **Nonnative aquatic plants.** Nutrients affect the productivity of aquatic macrophytes (plants visible to the naked eye) and the structure of the aquatic plant community (Wetzel 2001). Two nonnative aquatic plants, Brazilian waterweed and water hyacinth, have become particularly problematic in the Delta. Scientific studies have documented the distribution and spread of these invasive aquatic plants in the Delta (Underwood et al. 2006, Hestir et al. 2008, Khanna et al. 2011, Santos et al. 2011). The role of nutrient enrichment in the spread and productivity of these nonnative aquatic plants is unknown. Further research is required on the potential links between invasive aquatic plants in the Delta and nutrient inputs.

The effects of increased nutrient inputs also need to be considered in light of anticipated changes in the Delta with regard to lowered turbidity and warming temperatures. Figure 6-2 shows increasing nutrients in the Delta over time. As discussed in the following section, nutrients have been implicated in DO depletion in Delta channels due to the stimulation of plant growth with subsequent death and decay, and the microbial conversion of total ammonia to nitrate through the process of nitrification.

Dissolved Oxygen

DO in water is essential to the survival of most fish and many other aquatic organisms. Depletion of DO in a water body because of decaying organic matter is a classic water quality problem that can result in clear signs of pollution, including fish kills and foul odors. Low DO concentrations also can have less obvious effects. DO events occur regularly in the channels of Suisun Marsh and the Stockton Deep Water Ship Channel (SDWSC) and sporadically elsewhere in the Delta, with several waterways listed as impaired by the RWQCB.

One of the most significant water quality issues affecting the Delta in recent decades has been low DO episodes (DO concentrations less than regulatory objectives) in the SDWSC reach of the San Joaquin River in the Delta, which were thought to act as a barrier to salmon migration (Central Valley RWQCB 2005). Until the last few years, low DO events were a regular occurrence in this part of the Delta primarily during the summer and fall months.

The SDWSC DO problem has existed since at least the 1960s. The Central Valley RWQCB added this segment of the Delta to its list of impaired water bodies in 1998, and adopted a TMDL in 2005 that follows a phased approach requiring studies and initial actions followed by reconsideration of TMDL requirements in 2012. Extensive studies have identified several contributing factors, including inputs of algae from upstream (probably related to nutrient loads), discharges of total ammonia from the Stockton Regional Wastewater Control Facility (RWCF), increased channel depth due to dredging, and reduced net flows (Central Valley RWQCB 2005). See sidebar, Applying Adaptive Management in Water Quality Decisions, for more information about an adaptive management approach to DO in the SDWSC.

The improved wastewater treatment processes at the RWCF were fully operational starting in 2006. This, along with other discharge reductions upstream, appears to have greatly reduced the frequency and severity of low DO episodes in the SDWSC. The California Department of Water Resources (DWR) aeration facility also has been shown to be an effective remedy for the occasional DO depletion problem that might occur under current conditions. The actions taken to

Nutrients Create Delta Water Problems

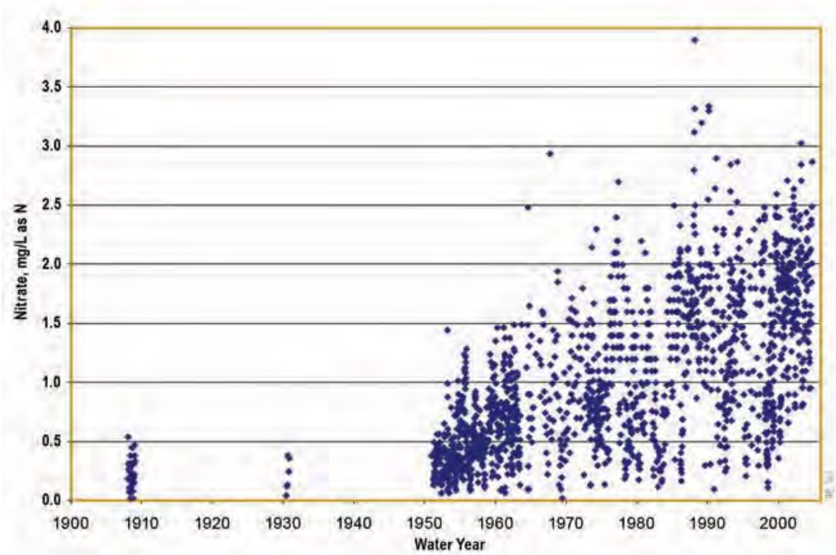


Figure 6-2 Nitrate concentrations at the point where the San Joaquin River enters the Delta dating back to 1908 show how much this important plant nutrient has increased. High nutrient concentrations are linked to a variety of problems including DO depletion, growth of nuisance aquatic plants, and taste and odor problems in drinking water.

Source: Adapted by the Delta Stewardship Council with data provided by USGS

comply with the current TMDL, along with improved flows and load reductions in the San Joaquin River watershed, appear to have provided a solution to this longstanding water quality problem. If continued, the actions taken to comply with the SDWSC TMDL should be sufficient to prevent future DO depletion problems.

The DO depletion problems in Suisun Marsh are caused by seasonal operations of ponds and wetlands managed for waterfowl hunting. For most of the year, duck club ponds are drained and occasionally flooded to promote the growth of plants that are the favored food of water fowl. When these ponds are flooded for hunting in the late summer and fall, the decay of accumulated plant matter followed by tidal exchanges of water with adjoining channels can cause severe DO depletion. Some of these low DO events have caused documented fish kills. The San Francisco Bay RWQCB has started the TMDL process to address DO depletion in Suisun Marsh.

The best pathways to address other Delta low DO problems will vary with local conditions and causes, but likely will be a combination of reduced loadings of oxygen-demanding substances and changes to flow conditions, under the framework of adaptive management. As TMDLs are developed to address low DO concentrations in the Delta, actions needed to improve DO conditions will be implemented through SWRCB and RWQCB programs, including NPDES permits, stormwater NPDES permits, WDRs, waivers of WDRs, and water rights. Low DO conditions in the Delta need to be addressed to prevent these conditions from increasing in extent and severity.

Applying Adaptive Management in Water Quality Decisions			An adaptive management approach to water quality control decisions should be taken to plan for and assess their outcomes. The following is an example of how the Council's three-stage, nine-step adaptive management framework (see Appendix C) was used for water quality decision making in the TMDL process to improve DO concentrations in the SDWSC.
Adaptive Management Step			**Improving DO Concentrations in the SDWSC**
Plan	1	Define/redefine the problem	Low concentrations of DO in the SDWSC periodically exceeded the Central Valley Basin Plan water quality objectives for DO for many years. Low DO acted as a barrier to migrating salmon.
	2	Establish goals, objectives, and performance measures	**Goal:** Meet the water quality objectives for DO in the SDWSC. **Objectives:** Maintain minimum DO concentrations of 5 milligrams per liter (mg/L) at all times and 6 mg/L September through November.
	3	Model linkages between objectives and proposed action(s)	Hydrodynamic and water quality models informed the development of a Physical and Chemical Processes Conceptual Model and a Biological and Ecological Effects Conceptual Model. The models identified at least four primary factors or processes influencing oxygen concentrations: (1) San Joaquin River flow through the SDWSC, (2) SDWSC volume, (3) algae and oxygen-demanding substances from the San Joaquin River upstream of the SDWSC, and (4) oxygen-demanding substances, including ammonia discharged from the RWCF. http://www.sjrdotmdl.org/concept_model/index.htm
	4	Select action(s) (research, pilot, or full-scale) and develop performance measures	**Selected Actions:** (1) Conduct studies to identify causes for the low DO levels and assign responsibility to correct the problem; (2) reduce RWCF ammonia discharges to the San Joaquin River; and (3) construct a Demonstration Dissolved Oxygen Aeration Facility (Aeration Facility). **Performance Measures:** ▪ Administrative – Implement Phase 1 TMDL actions. ▪ Output – Implement studies; select wastewater treatment improvements to reduce ammonia discharges including engineered wetlands and nitrifying bio-towers; develop pilot-scale aeration project. ▪ Outcome – DO concentrations are maintained at or above the water quality objectives for DO. Aquatic life, including resident and migratory fish, is not affected by low DO conditions.
Do	5	Design and implement action(s)	**Selected Actions:** (1) Conduct ongoing studies to improve the conceptual models; (2) add engineered wetlands and two nitrifying bio-towers to the RWCF; and (3) design, build, and operate the Aeration Facility at Rough and Ready Island to determine its applicability for increasing DO concentrations in the SDWSC.
	6	Design and implement monitoring plan	Collect baseline DO data prior to aerator operations. Conduct ongoing studies to test the understanding of linkages in the conceptual models. Conduct compliance monitoring at the RWCF as required by the permit. Conduct performance monitoring of the Aeration Facility to measure achievement of the target (increased DO concentrations in the SDWSC).
Evaluate and Respond	7	Analyze, synthesize, and evaluate	Technical Working Group will assess the study results and aeration pilot-study results.
	8	Communicate current understanding	Technical reports, study results, and web-based conceptual models were developed and maintained on a website. Pilot Report Aeration System and staff presentation to the Central Valley RWQCB (February 3, 2011).
	9	Adapt	Development of a revised control program (Phase 2 TMDL) including identification of additional or modified actions. Development of an aeration agreement with long-term funding for operation and maintenance of the Aeration Facility, including possible future modifications. Development of a system-level (long-term) monitoring plan for the Aeration Facility. Periodic review of control program actions and aerator operations.

Pesticides

Pesticides include insecticides, herbicides, fungicides, and various other substances used to control pests. In the Bay-Delta region, the primary pesticides of concern include the organophosphorus pesticides (for example, diazinon and chlorpyrifos), pyrethroid insecticides, and the legacy organochlorine pesticides (for example, DDT, chlordane, and dieldrin). These substances are known to have adverse impacts on aquatic organisms or, in some cases (as with the organochlorine pesticides), birds and mammals.

The Sacramento, San Joaquin, and Feather rivers; the Delta; and numerous agriculturally dominated streams in the Central Valley are either listed as impaired or are covered under an existing TMDL for pesticides (Central Valley RWQCB 1998, 2006). Delta waterways were placed on the CWA section 303(d) list for diazinon and chlorpyrifos due to aquatic toxicity (SWRCB 2010).

Smaller agriculturally dominated waterways and urban creeks are particularly vulnerable to toxicity from pesticides. Although agriculture is considered the primary source of pesticide impairment in the Central Valley and Delta, urban sources are also locally important (Kuivila and Hladik 2008). Some of the highest pesticide concentrations have been observed in residential area creeks and waters receiving urban runoff (Weston et al. 2005). Pyrethroid insecticides, which are common replacements for the organophosphorus pesticides, have been implicated as the principal pesticides causing toxicity in surface water samples collected from throughout California (Hunt et al. 2010).

Aquatic invertebrates in the water column are the organisms most affected by chlorpyrifos and diazinon exposure (Giddings et al. 2000); however, pyrethroids—because of their high potential to stick to organic matter—also can affect sediment-dwelling organisms (Werner and Oram 2008, Weston et al. 2004). Pyrethroid pesticides from multiple runoff sources have been found at levels toxic to aquatic invertebrates (Weston et al. 2005, Weston 2010).

Contaminants cannot be eliminated as a possible contributor to the declines in open-water fish populations in the Delta (known as pelagic organism decline [POD]). Johnson et al. (2010) reported that insufficient data are available to determine whether contaminants played an important role in the POD. Research on the role of contaminants in the POD continues with efforts under way to better define the presence of contaminants in the environment, the effects of contaminant mixtures, sublethal effects of contaminants on the POD species, and the effects of contaminants on prey organisms (Baxter et al. 2010). Synergistic effects of pesticide mixtures have been demonstrated for other species including juvenile salmon (Laetz et al. 2009).

Mercury

The Delta and many Delta tributaries are included in the SWRCB's section 303(d) list of impaired water bodies due to mercury contamination (Central Valley RWQCB 2009). Historical mercury mining in California's Coast Ranges and mercury use associated with gold mining in the Sierra Nevada over a century ago have left an environmental legacy of pervasive mercury contamination in many Northern California watersheds (Alpers and Hunerlach 2000). The current regulatory approach for mercury includes the mercury TMDL adopted by the San Francisco Bay RWQCB in 2006 and the Delta methylmercury TMDL adopted by the Central Valley RWQCB in 2010. Unfortunately, however, mercury is likely to persist in California's environment for many years to come.

Mercury is transformed into methylmercury by bacteria in the environment. Methylmercury, initially present at very low concentrations, enters the aquatic food web and can accumulate to levels of concern in long-lived fish at the top of the aquatic food chain, such as striped bass and largemouth bass. Methylmercury has been found in some types of Delta fish at concentrations that may be harmful to human health. The State has issued health advisories for fish consumption due to mercury contamination for a number of water bodies in the Delta and its watersheds. Mercury contamination of fish is of particular concern for people who are frequent consumers of Delta fish (Shilling 2009).

There is general concern that increased concentrations of methylmercury in water, sediment, and plants and animals might result from restoration of wetland and floodplain habitats in the Delta and, thus, must be carefully planned and monitored to minimize the production of methylmercury. For instance, the restoration of wetlands, particularly in areas where the abundance of mercury in soils or sediments is elevated, could accelerate the production of methylmercury and increase the contamination of aquatic plants and animals (Naimo et al. 2000, Wiener and Shields 2000). Additionally, flooding of wetlands or uplands, or fluctuating water levels during tidal cycles could stimulate methylmercury production and transport, thereby increasing concentrations of methylmercury in water and in plants and animals (Hecky et al. 1991, Hall et al. 1998, Paterson et al. 1998, Bodaly and Fudge 1999). Increased methylmercury production is a significant concern for planned wetland and floodplain ecosystem restoration projects, and should be monitored.

Further study is needed to determine the dominant processes affecting methylmercury concentrations in food webs in the Delta. The CALFED Ecosystem Restoration Program developed a framework (Mercury Strategy) for monitoring, research, risk communication, and adaptive management to address mercury problems in the Bay-Delta system (Wiener et al. 2003). The approach taken by the Central Valley RWQCB in its Delta Mercury Control Program, adopted April 22, 2010, is consistent with the Mercury Strategy (Central Valley RWQCB 2010).

Selenium

Selenium, a naturally occurring element, is an essential nutrient at low concentrations for humans and other organisms. However, higher concentrations can be toxic to fish and wildlife. Once selenium enters the aquatic environment, it has a high potential to bioaccumulate in zooplankton and benthic (bottom-dwelling) invertebrates and, subsequently, to biomagnify in the food web as it reaches top-level predators such as fish, birds, and mammals (Skorupa and Ohlendorf 1991, Fan et al. 2002, Hamilton 2004, Stewart et al. 2004, Paveglio and Kilbride 2007).

The major source of selenium loading to San Francisco Bay is the San Joaquin River, which receives selenium-laden agricultural drainage waters from the western San Joaquin Valley (Luoma and Presser 2000). Other sources of selenium loading include oil refineries, municipal and industrial wastewater, urban and nonurban runoff, atmospheric deposition, and erosion and sediment transport from within the north San Francisco Bay. Improved wastewater treatment at petroleum refineries discharging into San Francisco Bay has reduced the amount of selenium discharged, but these facilities are still the most significant point source of this pollutant (San Francisco Bay RWQCB 2011b).

Recent monitoring results indicate that selenium water column concentrations in the north San Francisco Bay are much lower than the current 5-parts per billion objective for chronic exposure (San Francisco Bay RWQCB 2011b). However, levels of selenium in aquatic organisms and fish show that the current regulatory criteria may not be sufficient. Despite progress to reduce selenium in the Bay-Delta system, levels in the food chain are still of concern. Selenium has been identified as a possible contributing factor to the observed decline of white sturgeon, Sacramento splittail, starry flounder, and diving ducks such as surf scoters. The focus of regulatory efforts at the State and national level is shifting from water-column concentrations to the concentration of selenium in the tissues of affected organisms (San Francisco Bay RWQCB 2011b).

Historically, portions of the San Joaquin River downstream of Grasslands, Salt Slough, and Mud Slough contained elevated levels of selenium from agricultural drainage (Saiki et al. 1993). The discharge of selenium from this area also has been significantly reduced from historical levels under a control program administered by Central Valley RWQCB, with plans for further reductions through 2019 (Reclamation 2009).

Contaminants of Emerging Concern

The term "contaminants of emerging concern" refers to a broad class of largely unregulated compounds for which there is concern that adverse effects might occur at environmentally significant concentrations. Examples of manufactured chemicals frequently found in water bodies and organisms include flame retardants, pesticides, human and veterinary pharmaceuticals, and ingredients in personal care products (Kolpin et al. 2002, Daughton 2004, Hoenicke et al. 2007).

Contaminants of emerging concern include many manufactured chemicals. These manufactured chemicals have the potential to alter water quality because of their widespread use, pathways to the environment, and potency. The primary sources for most contaminants of emerging concern include effluent from wastewater treatment plants, agricultural fields, and stormwater runoff. Many chemicals identified as contaminants of emerging concern have not been tested for their potential toxic effects on aquatic life. Most emerging pollutant maximum concentrations in the environment are well below established lethal concentration values for even the most sensitive aquatic species. Sublethal and chronic low-level exposures are of primary concern (Oros 2003, Brander et al. 2009, Ostrach 2009).

Regulatory and chemical monitoring programs should adapt to the quickly changing mix of contaminants of emerging concern identified through current studies and the peer-reviewed scientific literature (best available science). Effective management of contaminants of emerging concern in the Delta will require responsible agencies to perform appropriate scanning-level activities to prioritize a specific list of pollutants of highest concern and to develop or require work plans for special studies, and to conduct or require monitoring in accordance with the work plans. To this end, in 2011, the SWRCB established a Science Advisory Panel to address contaminants of emerging concern in aquatic ecosystems. The panel completed a report in April 2012 that included several recommendations for how the SWRCB should monitor and assess potential impacts of contaminants of emerging concern (Anderson et al. 2012).

POLICIES AND RECOMMENDATIONS

Policies and recommendations to address the water quality issues discussed in the preceding sections are based on the following strategies:

- Require Delta-specific water quality protection
- Protect beneficial uses by managing salinity
- Improve drinking water quality
- Improve environmental water quality

These major aspects of water quality are critical to achieving the coequal goals. The approach described here includes augmenting or accelerating existing programs where it is feasible to address an existing or anticipated water quality problem. The SWRCB and RWQCBs have broad authority to protect and regulate water quality; therefore, this chapter sets forth priority Delta-specific recommendations and does not contain regulatory policies at this time.

Require Delta-specific Water Quality Protection

Water flow, water quality, water supply, and habitat conditions in the Delta are distinctly different from other parts of the watershed and from San Francisco Bay downstream. The Delta is the most valuable estuary and wetland ecosystem on the West Coast of North and South America (Water Code section 85002), and is the primary habitat for a number of special-status species. Many communities in and around the Delta draw their drinking water directly from Delta waterways. Delta waterways also receive urban stormwater, treated wastewater, agricultural drainage, and drainage from managed wetlands. Studies have shown that such discharges can have significant impacts on water quality. These impacts are often more severe near the point of discharge. Stormwater, wastewater, and agricultural drainage discharges into the Delta should be managed so that they do not pose a significant risk to the beneficial uses of water in the Delta.

Problem Statement

Water quality management approaches developed for general application statewide or in other regions may not be sufficient for the unique and dynamic conditions of the Delta, its biological resources, and critical water supply services. Water supplies and habitats for special-status species require proactive and anticipatory measures for water quality protection consistent with their importance in achieving the coequal goals.

Policies

No policies with regulatory effect are included in this section.

Recommendations

WQ R1. Protect Beneficial Uses

Water quality in the Delta should be maintained at a level that supports, enhances, and protects beneficial uses identified in the applicable State Water Resources Control Board or regional water quality control board water quality control plans.

WQ R2. Identify Covered Action Impacts

Covered actions should identify any significant impacts to water quality.

WQ R3. Special Water Quality Protections for the Delta

The State Water Resources Control Board or regional water quality control board should evaluate and, if appropriate, propose special water quality protections for priority habitat restoration areas identified in recommendation ER R2 or other areas of the Delta where new or increased discharges of pollutants could adversely impact beneficial uses.

Protect Beneficial Uses by Managing Salinity

Beneficial uses within the Delta include drinking water, agriculture, and ecosystem protection. Salinity potentially affects these uses, but to varying degrees. The primary sources of salinity in the Delta are from tidal seawater intrusion from the Pacific Ocean through the San Francisco Bay, and to a lesser extent from agricultural and other discharges in the Central Valley. Historically, natural flows through the Delta regulated salinity in a way that favored the Delta ecosystem. Today, salinity in the Delta is dominated by the effects of upstream water diversions and use of the Delta to convey flows to Central and Southern California. The SWRCB is responsible for ensuring protection of beneficial uses through regulation of pollutant discharges, and regulation of water diversions and flows under their water rights authority.

Problem Statement

Salinity affects Delta agricultural, municipal, and environmental beneficial uses, but in different ways. Salinity and flow conditions in the Delta are affecting ecosystem, agricultural, and municipal uses. The timing and distribution of salinity is primarily affected by flow, which is largely determined by water management in the Delta and its watersheds as determined by applicable flow objectives. Delta conditions have changed since the current Delta flow objectives were adopted, and new scientific information about salinity, flow, and their effects on beneficial uses is available.

Policies

ER P1 in Chapter 4 on the SWRCB's Delta Flow Objectives addresses this issue.

Recommendations

ER R1 in Chapter 4 on the SWRCB's Update of Delta Flow Objectives addresses this issue.

Improve Drinking Water Quality

Millions of Californians entirely or partially rely on the Delta as a drinking water supply, and the future quality of that water supply is uncertain. Contamination of groundwater supplies places greater demand on surface waters that are tributary to the Delta for urban and agricultural users. Current water quality regulations and policies for surface waters do not apply directly to many of the drinking water quality constituents of concern. Sea level rise, levee failure, salinity variability, agricultural water use, and increased urban runoff from population growth in the watershed all pose a threat to drinking water quality. To prevent such degradation, we need clear policies regarding the protection of water quality relevant to the drinking water quality constituents of concern. The Central Valley RWQCB's anticipated drinking water policy is intended, in part, to prevent the degradation of high-quality drinking water sources (Central Valley RWQCB 2010).

In 2006, the SWRCB, the Central Valley RWQCB, and stakeholders began a joint effort to address salinity and nitrate problems in California's Central Valley and adopt long-term solutions that will lead to enhanced water quality and economic sustainability. Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS) is a collaborative basin planning effort aimed at developing and implementing a comprehensive salinity and nitrate management program.

Problem Statement

Delta drinking water supplies are degraded by inputs from sea water, regional soils, and sediments; from agricultural, urban, and industrial sources from the watershed; and from in-Delta sources.

Policies

No policies with regulatory effect are included in this section.

Recommendations

WQ R4. Complete Central Valley Drinking Water Policy

The Central Valley Regional Water Quality Control Board should complete the Central Valley Drinking Water Policy by July 2013.

WQ R5. Complete North Bay Aqueduct Alternative Intake Project

The California Department of Water Resources should complete the North Bay Aqueduct Alternate Intake Project Environmental Impact Report by December 31, 2012, and begin construction as soon as possible thereafter.

WQ R6. Protect Groundwater Beneficial Uses

The State Water Resources Control Board should complete development of a Strategic Workplan for protection of groundwater beneficial uses, including groundwater use for drinking water, by December 31, 2012.

WQ R7. Participation in CV-SALTS

The State Water Resources Control Board and Central Valley Regional Water Quality Control Board should consider requiring participation by all relevant water users that are supplied water from the Delta or the Delta watershed or discharge wastewater to the Delta or the Delta watershed to participate in the Central Valley Salinity Alternatives for Long-Term Sustainability Program.

Improve Environmental Water Quality

A variety of pollutants are discharged into Delta and tributary waters. These pollutants affect Delta biological species and ecosystem processes. Pollutants of concern include nutrients, pesticides, mercury, selenium, and other persistent bioaccumulative toxic substances. Newly identified pollutants of potential concern (emerging contaminants) also need to be investigated.

Problem Statement

Pollutants contained in municipal, industrial, agricultural, other nonpoint source discharges, and legacy sources flowing into the Delta and its tributary waterways, including pollutants that bioaccumulate and biomagnify in the food web, impair the Delta ecosystem. Evidence from water quality and ecosystem monitoring continues to show that significant water pollution problems persist in the Bay-Delta system and the Central Valley. Insufficient funding and support could lead to slowing or even erminating the SWRCB and the San Francisco Bay and Central Valley RWQCBs' engagements in regulatory processes, research, and monitoring that are essential to improving water quality in the Delta.

Policies

No policies with regulatory effect are included in this section.

Recommendations

WQ R8. Completion of Regulatory Processes, Research, and Monitoring for Water Quality Improvement

The State Water Resources Control Board and the San Francisco Bay and Central Valley Regional Water Quality Control Boards are currently engaged in regulatory processes, research, and monitoring essential to improving water quality in the Delta. In order to achieve the coequal goals, it is essential that these ongoing efforts be completed and, if possible, accelerated, and that the Legislature and Governor devote sufficient funding to make this possible. The Delta Stewardship Council specifically recommends that:

- *The State Water Resources Control Board should complete development of the proposed policy for nutrients for inland surface waters of the State of California by January 1, 2014.*
- *The State Water Resources Control Board and the San Francisco Bay and Central Valley Regional Water Quality Control Boards should prepare and begin implementation of a study plan for the development of objectives for nutrients in the Delta and Suisun Marsh by January 1, 2014. Studies needed for development of Delta and Suisun Marsh nutrient objectives should be completed by January 1, 2016. The water boards should adopt and begin implementation of nutrient objectives, either narrative or numeric, where appropriate, for the Delta and Suisun Marsh by January 1, 2018.*
- *The State Water Resources Control Board and the Central Valley Regional Water Quality Control Board should complete the Central Valley Pesticide Total Maximum Daily Load and Basin Plan Amendment for diazinon and chlorpyrifos by January 1, 2013.*
- *The State Water Resources Control Board and the Central Valley Regional Water Quality Control Board should prioritize and accelerate the completion of the Central Valley Pesticide Total Maximum Daily Load and Basin Plan Amendment for pyrethroids by January 1, 2016.*
- *The State Water Resources Control Board and the San Francisco Bay and Central Valley Regional Water Quality Control Boards have completed Total Maximum Daily Load and Basin Plan Amendments for methylmercury, and efforts to support their implementation should be coordinated. Parties identified as responsible for current methylmercury loads or proponents of projects that may increase*

methylmercury loading in the Delta or Suisun Marsh should participate in control studies or implement site-specific study plans that evaluate practices to minimize methylmercury discharges. The Central Valley Regional Water Quality Control Board should review these control studies by December 31, 2018 and determine control measures for implementation starting in 2020.

WQ R9. Implement Delta Regional Monitoring Program

The State Water Resources Control Board and Regional Water Quality Control Boards should work collaboratively with the California Department of Water Resources, California Department of Fish and Wildlife, and other agencies and entities that monitor water quality in the Delta to develop and implement a Delta Regional Monitoring Program that will be responsible for coordinating monitoring efforts so Delta conditions can be efficiently assessed and reported on a regular basis.

WQ R10. Evaluate Wastewater Recycling, Reuse, or Treatment

The Central Valley Regional Water Quality Control Board, consistent with existing water quality control plan policies and water rights law, should require responsible entities that discharge wastewater treatment plant effluent or urban runoff to Delta waters to evaluate whether all or a portion of the discharge can be recycled, otherwise used, or treated in order to reduce contaminant loads to the Delta by January 1, 2014.

WQ R11. Manage Dissolved Oxygen in Stockton Ship Channel

The State Water Resources Control Board and the Central Valley Regional Water Quality Control Board should complete Phase 2 of the Total Maximum Daily Load and Basin Plan Amendment for dissolved oxygen in the Stockton Deep Water Ship Channel by January 1, 2015.

WQ R12. Manage Dissolved Oxygen in Suisun Marsh

The State Water Resources Control Board and the San Francisco Bay Regional Water Quality Control Board should complete the Total Maximum Daily Load and Basin Plan Amendment for dissolved oxygen in Suisun Marsh wetlands by January 1, 2014.

Timeline for Implementing Policies and Recommendations

Figure 6-3 lays out a timeline for implementing the policies and recommendations described in the previous section. The timeline emphasizes near-term and intermediate-term actions.

Timeline for Implementing Policies and Recommendations

TIMELINE CHAPTER 6: Improve Water Quality

	ACTION (REFERENCE #)	LEAD AGENCY(IES)	NEAR TERM 2012–2017	INTERMEDIATE TERM 2017–2025
RECOMMENDATIONS	Protect beneficial uses (WQ R1)	Varies	●	●
	Identify covered action impacts (WQ R2)	Varies	●	●
	Special water quality protections for the Delta (WQ R3)	SWRCB, RWQCB	●	
	Complete Central Valley drinking water policy (WQ R4)	Central Valley RWQCB	●	
	Complete North Bay Aqueduct Alternative Intake Project (WQ R5)	DWR	●	
	Protect groundwater beneficial uses (WQ R6)	SWRCB	●	
	Participation in CV-SALTS* (WQ R7)	SWRCB and Central Valley RWQCB	●	
	Completion of regulatory processes, research, and monitoring for water quality improvements (WQ R8)	SWRCB, San Francisco Bay and Central Valley RWQCBs	●	
	Implement Delta regional monitoring program (WQ R9)	SWRCB and RWQCBs	●	
	Evaluate wastewater recycling, reuse, or treatment (WQ R10)	Central Valley RWQCB	●	
	Manage dissolved oxygen in Stockton Ship Channel (WQ R11)	SWRCB and Central Valley RWQCB	●	
	Manage dissolved oxygen in Suisun Marsh (WQ R12)	SWRCB and San Francisco Bay RWQCB	●	

*CV-SALTS: Central Valley Salinity Alternatives for Long-Term Sustainability Program

DP_345

Agency Key: DWR: California Department of Water Resources RWQCB: Regional Water Quality Control Board(s) SWRCB: State Water Resources Control Board

Figure 6-3

Science and Information Needs

Successful management of water quality depends on a well-designed, comprehensive, and consistent system of water quality monitoring. Current Delta water quality monitoring is fragmented among several different agencies and programs. The Central Valley RWQCB has initiated an effort to develop a Delta Regional Monitoring Program that will consolidate and coordinate most of the current monitoring. Developing a coordinated and thorough regional monitoring program is essential to performance measurement and adaptive management in the Delta.

As identified above, a number of outstanding science questions need to be resolved with respect to water quality. Additional study is needed on the following:

- The effects of salinity on introduced and native plant and animal species
- Trends in concentrations of drinking water constituents of concern
- The effects of nutrients on the Delta ecosystem and municipal water supplies
    - The importance of phytoplankton bloom suppression from ammonium
    - The role of nutrient loading on HABs in the Delta
    - Possible linkages between nonnative aquatic plants and nutrient inputs
- Controlling DO depletion
- The effects of the simultaneous presence of multiple pesticides, even at low levels, on species of concern
- The processes contributing to mercury and selenium compounds in food webs and their effects on the ecosystem
- The impacts of pharmaceutical compounds, personal care products, and other emerging contaminants on the ecosystem
- The combined effects of multiple contaminants and water quality conditions on the ecosystem
- Sources and impacts of pathogens on drinking water sources and recreation in the Delta
- An analysis and evaluation of existing water quality models in the Delta
- Fate and transport of water quality contaminants in the Delta

Issues for Future Evaluation and Coordination

Additional areas of interest and concern related to water quality and the Delta may deserve consideration in the development of future Delta Plan updates, including the following:

- **Small and disadvantaged communities:** Ensuring a safe drinking water supply can have a disproportionate cost for small and disadvantaged communities. Delta communities that are small and disadvantaged include Bethel Island, Courtland, Freeport, Hood, Isleton, Locke, and Walnut Grove. There are also small and disadvantaged communities in areas served by water exported from the Delta that are disproportionately impacted by nitrate and other groundwater pollutants. Available options to correct unsafe drinking water conditions include shared services and facilities; consolidation of several small systems into a single, larger system; centralized treatment; interim point-of-use treatment or use of bottled water; replacement of a contaminated source with an uncontaminated source; and, in the case of chemical contamination, blending of contaminated sources with uncontaminated sources. Consideration also must be given to the new State policy that "every human being has the right to safe, clean, affordable and accessible water adequate for human consumption, cooking, and sanitary purposes" (Water Code section 106.3(a)). Availability and prioritization of funding, restructuring of regulatory requirements, and provision of technical assistance may all be part of the solution, but involve the authority of various agencies including the California Department of Public Health, SWRCB, DWR, U.S. Department of Agriculture, and local cities and counties. An integrated effort including the input and involvement of the regulatory and affected agencies will be needed to properly address these issues and to refine effective recommendations.

- **Coordinated and prioritized water quality monitoring and modeling:** Various water quality monitoring and modeling efforts are ongoing, but are not coordinated among affected agencies. Agencies involved in these efforts include the SWRCB, RWQCBs, DWR, the Interagency Ecological Program, California Department of Fish and Wildlife, and now, the Council. Collective discussion and evaluation by these and other entities will be needed in order to make recommendations regarding the need for and prioritization of water quality modeling in the Delta.
- **Contaminants of emerging concern:** The SWRCB and RWQCBs should continue ongoing efforts to address contaminants of emerging concern. This work should include development of a work plan for conducting or requiring special studies of pollutants, including emerging contaminants and causes of toxicity in Delta waters and sediments.
- **Water quality objectives for selenium:** The identified sources of selenium as a contaminant and its potential to bioaccumulate and biomagnify in the environment are ongoing concerns. The SWRCB and San Francisco Bay and Central Valley RWQCBs should continue efforts to revise water quality objectives for selenium.

Performance Measures

Development of informative and meaningful performance measures is a challenging task that will continue after the adoption of the Delta Plan. Performance measures need to be designed to capture important trends and to address whether specific actions are producing expected results.

Efforts to develop and track performance measures in complex and large-scale systems like the Delta are commonly multiyear endeavors. The recommended output and outcome performance measures listed below are provided as examples, and subject to refinement as time and resources allow. Final administrative performance measures are listed in Appendix E and will be tracked as soon as the Delta Plan is completed.

Output Performance Measures

- DWR begins constructing the North Bay Aqueduct Alternate Intake Project as soon as possible after the environmental impact report is completed. (WQ R5)
- Progress toward reducing concentrations of inorganic nutrients (ammonium, nitrate, and phosphate) in Delta waters over the next decade. (WQ R8)
- TMDLs for critical pesticides (for example, diazinon, chlorpyrifos, and pyrethroids) in the waters and sediments of the Delta are met by 2020. (WQ R8)
- A Delta regional water quality monitoring program is implemented within the first 5 years of the Delta Plan. (WQ R9)

Outcome Performance Measures

- Water quality in the Delta meets objectives established in the applicable water quality control plan. (WQ R1)
- Trends in measureable toxicity from pesticides and other pollutants in Delta waters will be downward over the next decade. (WQ R8)
- Progress toward consistently meeting applicable DO standards in the Delta by 2020. (WQ R8, WQ R11, and WQ R12)
- HABs will lessen in severity and spatial coverage in the Delta over the next decade. (WQ R3 and WQ R8)
- The spatial distribution and productivity of nuisance nonnative aquatic plants will decline over the next decade. (WQ R3 and WQ R8)

References

Alpers, C. N. and M. P. Hunerlach. 2000. Mercury Contamination from Historic Gold Mining in California. U.S. Geological Survey Fact Sheet FS-061-00, Sacramento, California. 6 pp.

AWWA (American Water Works Association). 2011. *Water Quality and Treatment*. 1,696 pp.

Anderson, P. D., N. D. Denslow, J. E. Drewes, A. W. Olivieri, D. Schlenk, G. I. Scott, and S. A. Snyder. 2012. Technical Report 692. *Monitoring Strategies for Chemicals of Emerging Concern (CECs) in California's Aquatic Ecosystems: Recommendations of a Science Advisory Panel*. SCCWRP.

Baxter, R., R. Breuer, L. Brown, L. Conrad, F. Feyrer, S. Fong, K. Gehrts, L. Grimaldo, B. Herbold, P. Hrodey, A. Mueller-Solger, T. Sommer, and K. Souza. 2010. *Interagency Ecological Program 2010 Pelagic Organism Decline Work Plan and Synthesis of Results*. Interagency Ecological Program for the San Francisco Estuary.

Bodaly, R A., and R. J. P. Fudge. 1999. Uptake of mercury by fish in an experimental boreal reservoir. *Archives of Environmental Contamination and Toxicology* 37:103-109.

Brander, S. M., I. Werner, J. W. White, and L. A. Deanovic. 2009. Toxicity of a dissolved pyrethroid mixture to *Hyalella azteca* at environmentally relevant concentrations. *Environmental Toxicology and Chemistry* 28:1493–1499.

Central Valley Drinking Water Policy Workgroup. 2007. Conceptual Model for Salinity in the Central Valley and Sacramento-San Joaquin Delta. Prepared by the CALFED Bay-Delta Program. July.

Central Valley RWQCB (Regional Water Quality Control Board). 1998. *The Water Quality Control Plan for the California Regional Water Quality Control Board, Central Valley Region—The Sacramento River Basin and The San Joaquin River Basin*. Fourth Edition. Revised September 2009 (with approved amendments.)

Central Valley RWQCB (Regional Water Quality Control Board). 2005. *Amendments to the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins for the Control Program for Factors Contributing to the Dissolved Oxygen Impairment in the Stockton Deep Water Ship Channel*. February 2005 Final Staff Report.

Central Valley RWQCB (Regional Water Quality Control Board). 2006. *Amendments to the Water Quality Control Plan For the Sacramento River and San Joaquin River Basins for the Control of Diazinon and Chlorpyrifos Runoff into the Sacramento–San Joaquin Delta*. June 2006 Final Staff Report.

Central Valley RWQCB (Regional Water Quality Control Board). 2009. *Clean Water Act Section 305(b) and 303(d) Integrated Report for the Central Valley Region*.

Central Valley RWQCB (Regional Water Quality Control Board). 2010. Resolution No. R5-2010-0079 *Establishment of a Central Valley Drinking Water Policy for the Sacramento-San Joaquin Delta and Upstream Tributaries*.

Central Valley RWQCB (Regional Water Quality Control Board). 2011. Information compiled from website: TMDL and 303(d) List - TMDL Projects in the Central Valley Region. Accessed May. http://www.swrcb.ca.gov/centralvalley/water_issues/tmdl/central_valley_projects/index.shtml.

Chen, W., K. Haunschild, J. Lund, and W. Fleenor. 2010. Current and long-term effects of Delta water quality on drinking water treatment costs from disinfection byproduct formation. *San Francisco Estuary and Watershed Science* 8(3). http://escholarship.org/uc/item/0qf4072h.

Cloern, J., N. Knowles, L. Brown, D. Cayan, and M. Dettinger. 2011. Projected evolution of California's San Francisco Bay-Delta-River system in a century of climate change. *PLoS ONE* 6(9): e24465. doi:10.1371/journal.pone.0024465.

Daughton, C. 2004. Non-regulated water contaminants: emerging research. *Environmental Impact Assessment Reviews* 24:711–732.

DWR (California Department of Water Resources). 2007. *California State Water Project Watershed Sanitary Survey – 2006 Update*. http://www.water.ca.gov/waterquality/drinkingwater/docs/program_reports/calif_state_water_project_watershed_sanitary_survey_2006_update.pdf.

Dugdale, R. C., F. P. Wilkerson, V. E. Hogue, and A. Marchi. 2007. The role of ammonium and nitrate in spring bloom development in San Francisco Bay. *Estuarine, Coastal, and Shelf Science* 73:17-29.

Enright, C. and S. D. Culberson. 2010. Salinity trends, variability, and control in the northern reach of the San Francisco Estuary. *San Francisco Estuary and Watershed Science* 7(2). http://escholarship.org/uc/item/0d52737t.

Fan, T. W-M., S. J. Teh, D. E. Hinton, and R. M. Higashi. 2002. Selenium biotransformations into proteinaceous forms by foodweb organisms of selenium laden drainage waters in California. *Aquatic Toxicology* 57:65-84.

Feyrer, F., K. Newman, M. Nobriga, and T. Sommer. 2011. Modeling the effects of future outflow on the abiotic habitat of an imperiled estuarine fish. *Estuaries and Coasts* 34:120-128.

Giddings, J. M., L. W. Hall, Jr., and K. R. Solomon. 2000. Ecological risks of diazinon from agricultural use in the Sacramento–San Joaquin River Basins, California. *Risk Analysis* 20:545–572. doi: 10.1111/0272-4332.205052.

Glibert, P. M., D. Fullerton, J. M. Burkholder, J. C. Cornwell, and T. M. Kana. 2011. Ecological stoichiometry, biogeochemical cycling, invasive species, and aquatic food webs: San Francisco Estuary and Comparative Systems. *Reviews in Fisheries Science* 19:358-417.

Hall, B. D., D. M. Rosenberg, and A. P. Wiens. 1998. Methyl mercury in aquatic insects from an experimental reservoir. *Canadian Journal of Fisheries and Aquatic Sciences* 55:2036-2047.

Hamilton, S. J. 2004. Review of selenium toxicity in the aquatic food chain. *Science of the Total Environment* 326:1-31.

Hecky, R. E., D. J. Ramsey, R. A. Bodaly, and N. E. Strange. 1991. Increased methylmercury contamination in fish in newly formed freshwater reservoirs, in T. Suzuki et al. (Eds.), *Advances in Mercury Toxicology*. Plenum Press, New York. pp. 33–52.

Healey, M. C., M. D. Dettinger, and R. B. Norgaard, eds. 2008. *The State of Bay-Delta Science, 2008*. CALFED Science Program: Sacramento, CA, 174 pp.

Hestir, E. L., S. Khanna, M. E. Andrew, M. J. Santos, J. H. Viers, J. A. Greenberg, S. S. Rajapakse, and S. L. Ustin. 2008. Identification of invasive vegetation using hyperspectral remote sensing in the California Delta ecosystem. *Remote Sensing of Environment* 112:4034-4047.

Hoffman, G. J. 2010. *Salt Tolerance of Crops in the Southern Sacramento-San Joaquin Delta*. Report to the SWRCB.

Hoenicke, R., D. R. Oros, J. J. Oram, and K. M. Taberski. 2007. Adapting an ambient monitoring program to the challenge of managing emerging pollutants in the San Francisco Estuary. *Environmental Research* 105:132-144.

Howitt, R. E., J. Kaplan, D. Larson, D. MacEwan, J. Medellín-Azuara, G. Horner, and N. Lee. 2009. *The Economic Impacts of Central Valley Salinity*. Report to the California SWRCB. http://swap.ucdavis.edu/SWAPFiles/ReportsPapers/MainDocument_031909.pdf.

Hunt, J. W., D. Markiewica, and M. Pranger. 2010. *Summary of Toxicity in California Waters 2001-2009*. Report prepared for the Surface Water Ambient Water Program. November 2009.

Izaguirre, G., and W. D. Taylor. 2007. Geosmin and MIB events in a new reservoir in southern California. *Water Science and Technology* 55:9-14.

Johnson, M. L., I. Werner, S. Teh, and F. Loge. 2010. *Evaluation of Chemical Toxicological, and Histolopathologic Data to Determine Their Role in the Pelagic Organism Decline*. Report to the SWRCB. http://www.waterboards.ca.gov/centralvalley/water_issues/delta_water_quality/comprehensive_monitoring_program/contaminant_synthesis_report.pdf.

Khanna, S., M. J. Santos, and S. L. Ustin. 2011. An integrated approach to a biophysiologically based classification of floating aquatic macrophytes. *International Journal of Remote Sensing* 32:1067-1094.

Kimmerer, W. J. 2004. Open water processes of the San Francisco estuary: from physical forcing to biological responses. *San Francisco Estuary and Watershed Science* 2(1).

Kolpin, D. W., E. T. Furlong, M. T. Meyer, E. M. Thurman, S. D. Zaugg, L. B. Barber, and H. T. Buxton. 2002. Pharmaceuticals, hormones, and other organic wastewater contaminants in U.S. streams, 1999–2000: A national reconnaissance. *Environmental Science and Technology* 36:1202-1211.

Kraus, T. E. C., B. A. Bergamaschi, P. J. Hernes, R. G. M. Spencer, R. Stepanauskas, C. Kendall, R. F. Losee, and R. Fujii. 2008. Assessing the contribution of wetlands and subsided islands to dissolved organic matter and disinfection byproduct precursors in the Sacramento-San Joaquin River Delta: A geochemical approach. *Organic Geochemistry* 39: 1302-1318.

Kuivila, K., and M. Hladick. 2008. Understanding the occurrence and transport of current-use pesticides in the San Francisco estuary watershed. *San Francisco Estuary and Watershed Science* 6(3). http://escholarship.org/uc/item/06n8b36k.

Laetz, C. A., D. H. Baldwin, T. K. Collier, V. Hebert, J. D. Stark, and N. L. Scholz. 2009. The synergistic toxicity of pesticide mixtures: Implications for risk assessment and the conservation of endangered Pacific Salmon. *Environmental Health Perspectives* 117:348-353.

Leenheer, J. A., and J. P. Croue. 2003. Characterizing aquatic dissolved organic matter. *Environmental Science and Technology* 37, 18A-26A.

Lehman, P. W., G. Boyer, C. Hall, S. Waller, and K. Gehrts. 2005. Distribution and toxicity of a new colonial *Microcystis aeruginosa* bloom in the San Francisco Bay Estuary, California. *Hydrobiologia* 541:87-99.

Lehman, P. W., G. Boyer, M. Satchwell, and S. Waller. 2008. The influence of environmental conditions on the seasonal variation of Microcystis cell density and microcystins concentration in San Francisco Estuary. *Hydrobiologia* 600:187-204.

Luoma, S. N., and T. S. Presser. 2000. *Forecasting Selenium Discharges to the San Francisco Bay-Delta Estuary: Ecological Effects of a Proposed San Luis Drain Extension.* U.S. Geological Survey Open-File Report 00-416.

Malamud-Roam, F., and B. L. Ingram. 2004. Late Holocene delta13C and pollen records of paleosalinity from tidal marshes in the San Francisco Bay estuary, California. *Quaternary Research* 62:134-145.

Malamud-Roam, F., M. Dettinger, B. L. Ingram, M. K. Hughes, and J. L. Florsheim. 2007. Holocene climates and connections between the San Francisco Bay Estuary and its watershed: A review. *San Francisco Estuary and Watershed Science* 5(1).

Moyle, P. B. 2002. *Inland Fishes of California*. University of California Press. Berkeley, CA.

Naimo, T. J., J. G. Wiener, W. G. Cope, and N. S. Bloom. 2000. Bioavailability of sediment-associated mercury to Hexagenia mayflies in a contaminated floodplain river. *Canadian Journal of Fisheries and Aquatic Sciences* 57:1092-1102.

Nobriga, M., T. Sommer, F. Feyrer, and K. Fleming. 2008. Long-term trends in summertime habitat suitability for Delta smelt (*Hypomesus transpacificus*). *San Francisco Estuary and Watershed Science* 6(1).

Oros, D. R., W. M. Jarman, T. Lowe, N. David, S. Lowe, and J. A. Davis. 2003. Surveillance for previously unmonitored organic contaminants in the San Francisco Estuary. *Marine Pollution Bulletin* 46:1102–1110.

Ostrach, D. J. 2009. *The Role of Contaminants, within the Context of Multiple Stressors, in the Collapse of the Striped Bass Population in the San Francisco Estuary and Its Watershed*. Year 2 Final Report for DWR Agreement No. 4600004664.

Pacific Institute. 2011. *The Human Costs of Nitrate-contaminated Drinking Water in the San Joaquin Valley*.

Paterson, M. J., J. W. M. Rudd, and V. St. Louis. 1998. Increases in total and methylmercury in zooplankton following flooding of a peatland reservoir. *Environmental Science and Technology* 32:3868-3874.

Paveglio, F. L., and K. M. Kilbride. 2007. Selenium in aquatic birds from Central California. *The Journal of Wildlife Management* 71:2550-2555.

Reclamation (Bureau of Reclamation). 2009. *Grassland Bypass Project, 2010–2019, Environmental Impact Statement and Environmental Impact Report*. http://www.usbr.gov/mp/nepa/documentShow.cfm?Doc_ID=4412.

Saiki, M. K., M. R. Jennings, and W. G. Brumbaugh. 1993. Boron, molybdenum, and selenium in aquatic food chains from the lower San Joaquin River and its tributaries, California. *Archives of Environmental Contamination and Toxicology* 24:307-319.

San Francisco Bay RWQCB (Regional Water Quality Control Board). 2011a. Information compiled from website: Total Maximum Daily Loads (TMDLs) and the 303(d) List of Impaired Water Bodies. Accessed May. http://www.swrcb.ca.gov/sanfranciscobay/water_issues/programs/TMDLs/.

San Francisco Bay RWQCB (Regional Water Quality Control Board). 2011b. *Total Maximum Daily Load Selenium in North San Francisco Bay*. Preliminary Project Report. January.

Santos, M. J., L. W. Anderson, and S. L. Ustin. 2011. Effects of invasive species on plant communities: An example using submersed aquatic plants at the regional scale. *Biological Invasions* 13:443-457.

Shilling, F. 2009. *Characterizing High Mercury Exposure Rates of Delta Subsistence Fishers*. Report for the Central Valley Regional Water Quality Control Board. pp.14. http://www.waterboards.ca.gov/rwqcb5/water_issues/tmdl/central_valley_projects/delta_hg/other_technical_reports/char_high_mercury_mem.pdf.

Skorupa, J. P., and H. M. Ohlendorf. 1991. Contaminants in drainage water and avian risk thresholds. In *The Economics and Management of Water and Drainage in Agriculture*, A. Dinar and D. Zolberman (eds.). Pages 345-368. Kluwer Academic Publishers, Boston.

Stahle, D. W., R. Griffin, M. Cleaveland, J. Edmondson, F. Fye, D. Burnette, J. Abatzoglou, K. Redmond, D. Meko, M. Dettinger, D. Cayan, and M. Therrell. 2011. A tree-ring reconstruction of the salinity gradient in the northern estuary of San Francisco Bay. *San Francisco Estuary and Watershed Science* 9(1).

Stewart, A. R., S. N. Luoma, C. E. Schlekat, M. A. Doblin, and K. A. Hieb. 2004. Food web pathway determines how selenium affects aquatic ecosystems: A San Francisco Bay case study. *Environmental Science and Technology* 38:4519-4526.

SWRCB (State Water Resources Control Board). 2006. *Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary*. SWRCB, California Environmental Protection Agency, Division of Water Rights. December 13.

SWRCB (State Water Resources Control Board). 2010. *The 2008-2010 Integrated Report. Clean Water Act Section 303(d) List of Water Quality Limited Segments*.

SWRCB (State Water Resources Control Board). 2011. Groundwater Ambient Monitoring and Assessment Program, Map of Hydrogeologically Vulnerable Areas. http://www.swrcb.ca.gov/water_issues/programs/gama/docs/hva_update.pdf.

Tetra Tech. 2006a. Conceptual Model for Nutrients in the Central Valley and Sacramento–San Joaquin Delta. http://www.swrcb.ca.gov/centralvalley/water_issues/drinking_water_policy/.

Tetra Tech. 2006b. Conceptual Model for Organic Carbon in the Central Valley and Sacramento–San Joaquin Delta. http://www.swrcb.ca.gov/centralvalley/water_issues/drinking_water_policy/.

Tetra Tech. 2007. Conceptual Model for Pathogens and Pathogen Indicators. http://www.swrcb.ca.gov/centralvalley/water_issues/drinking_water_policy/.

Underwood, E., M. Mulitsch, J. A. Greenberg, M. L. Whiting, S. L. Ustin, and S. C. Kefauver. 2006. Mapping invasive aquatic vegetation in the Sacramento–San Joaquin Delta using hyperspectral imagery. *Ecological Monitoring and Assessment* 121:47-64.

USEPA (U.S. Environmental Protection Agency). 2004. *Comprehensive Surface Water Treatment Rules Quick Reference Guide*. EPA 816-F-04-003. http://water.epa.gov/lawsregs/rulesregs/sdwa/swtr/index.cfm.

USEPA (U.S. Environmental Protection Agency). 2010. *Section 319 Nonpoint Source Success Stories California: Sacramento and Feather Rivers*. http://www.epa.gov/owow_keep/NPS/Success319/state/ca_sac.htm.

USEPA (U.S. Environmental Protection Agency). 2011. Water Quality Challenges in the San Francisco Bay/Sacramento–San Joaquin Delta Estuary. Unabridged Advanced Notice of Proposed Rulemaking.

Werner, I., and J. J. Oram. 2008. Pyrethroid Insecticides Conceptual Model. Sacramento (CA): Delta Regional Ecosystem Restoration Implementation Plan.

Weston, D. P., J. You, and M. J. Lydy. 2004. Distribution and toxicity of sediment-associated pesticides in agriculture-dominated water bodies of California's Central Valley. *Environmental Science and Technology* 38:2752-2759.

Weston, D. P., R. J. Holmes, J. You, and M. J. Lydy. 2005. Aquatic toxicity due to residential use of pyrethroid insecticides. *Environmental Science and Technology* 39:9778–9784.

Weston, D. P., and M. J. Lydy. 2010. Urban and agricultural sources of pyrethroid insecticides to the Sacramento–San Joaquin Delta of California. *Environmental Science and Technology* 44:1833-1840.

Wiener, J. G., and P. J. Shields. 2000. Mercury in the Sudbury River (Massachusetts, USA): pollution history and a synthesis of recent research. *Canadian Journal of Fisheries and Aquatic Sciences* 57:1053-1061.

Wiener, J. G., C. C. Gilmour, and D. P. Krabbenhoft. 2003. *Mercury Strategy for the Bay-Delta Ecosystem: A Unifying Framework for Science, Adaptive Management, and Ecological Restoration*. Final Report to the California Bay Delta Authority. Sacramento, CA. Accessed August 14, 2007. http://science.calwater.ca.gov/pdf/MercuryStrategyFinalReport.pdf.

Wetzel, R. G. 2001. *Limnology: Lake and River Ecosystems*. Third Edition. Academic Press, San Diego, CA.

Photo Credits

Chapter divider: *(clockwise from top left)***:** Delta Stewardship Council, California Department of Water Resources, Delta Conservancy

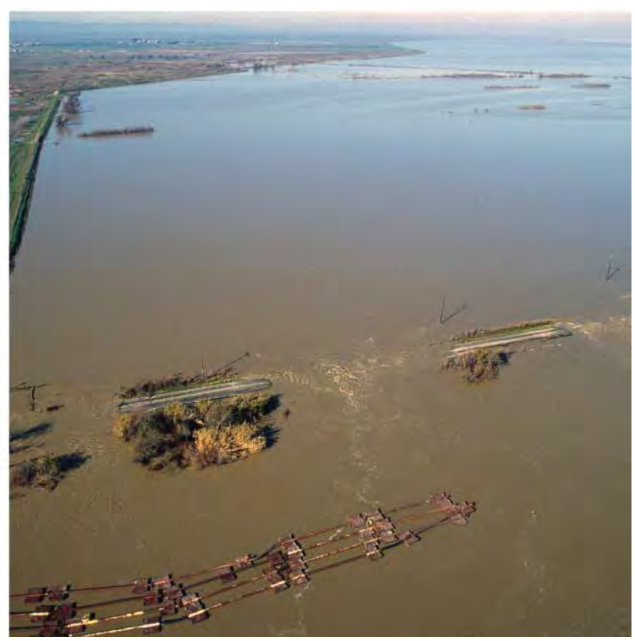
Page 223: Chris Austin

Page 229: Chris Austin

This page intentionally left blank.

CHAPTER 7

Reduce Risk to People, Property, and State Interests in the Delta



ABOUT THIS CHAPTER

This chapter provides an overview of flood risk in the Sacramento-San Joaquin Delta (Delta), current flood management efforts, and the most pertinent agencies and regulations. It details the Delta Stewardship Council's (Council) core strategies to reduce risk to people, property, and State interests in the Delta. These core strategies form the basis of the four policies and ten recommendations found at the end of the chapter:

- Improve emergency preparedness and response
- Finance and implement flood management activities
- Prioritize flood management investment
- Improve residential flood protection
- Protect and expand floodways, floodplains, and bypasses
- Integrate Delta levees and ecosystem function
- Limit liability

Reducing flood risks in the Delta also relies on locating urban development in the cities where levees are stronger (as proposed in Chapter 5) and retaining rural lands for agriculture, so that development in the most floodprone areas is minimized.

RELEVANT LEGISLATION

Water Code sections 85305, 85306, 85307, and 85309 require the Delta Plan to include or otherwise consider specific components to attempt to reduce risk.

85305(a) The Delta Plan shall attempt to reduce risks to people, property, and state interests in the Delta by promoting effective emergency preparedness, appropriate land uses, and strategic levee investments.

(b) The council may incorporate into the Delta Plan the emergency preparedness and response strategies for the Delta developed by the California Emergency Management Agency pursuant to Section 12994.5.

85306 The council, in consultation with the Central Valley Flood Protection Board, shall recommend in the Delta Plan priorities for state investments in levee operation, maintenance, and improvements in the Delta, including both levees that are a part of the State Plan of Flood Control and nonproject levees.

85307(a) The Delta Plan may identify actions to be taken outside of the Delta, if those actions are determined to significantly reduce flood risks in the Delta.

(b) The Delta Plan may include local plans of flood protection.

(c) The council, in consultation with the Department of Transportation, may address in the Delta Plan the effects of climate change and sea level rise on the three state highways that cross the Delta.

(d) The council, in consultation with the State Energy Resources Conservation and Development Commission and the Public Utilities Commission, may incorporate into the Delta Plan additional actions to address the needs of Delta energy development, energy storage, and energy transmission and distribution.

85309 The department, in consultation with the United States Army Corps of Engineers and the Central Valley Flood Protection Board, shall consider a proposal to coordinate flood and water supply operations of the State Water Project and the federal Central Valley Project, and submit the proposal to the council for considerations for incorporation into the Delta Plan. In drafting the proposal, the department shall consider all related actions set forth in the Strategic Plan.

This page intentionally left blank.

CHAPTER 7

Reduce Risk to People, Property, and State Interests in the Delta

Reducing flood risks to people, property, and State interests is critical to achieving the Delta Reform Act's coequal goals and protecting the Delta as a place. The Legislature has found that the Delta is "inherently floodprone," and that further improvements and continuing maintenance of the levee system will not resolve all flood risks (Public Resources Code section 29704). Living with risk, whether from floods, earthquakes, fires, coastal storms, or other hazards, is often part of life in California. The Delta's hazards, however, are exceptional because they affect so many State interests, including the reliability of its water supplies, the health of the Delta's ecosystem, and the qualities that make the Delta an attractive place to live, work, and recreate.

To reduce these risks to people, property, and State interests in the Delta, the Delta Reform Act requires that the Delta Plan promote effective emergency response and emergency preparedness, and promote appropriate land use (Water Code section 85305). The Delta Reform Act also directs the Council, in consultation with the Central Valley Flood Protection Board (CVFPB), to recommend priorities for State investments in levee operation, maintenance, and improvements in the Delta, including both levees that are a part of the State Plan of Flood Control and nonproject levees (Water Code section 85306).

The Council envisions a future in which risks of flooding in the Delta are reduced, despite an increase in sea levels and altered runoff patterns. The Council sees a future where Delta residents, local governments, and businesses are better prepared to respond when floods threaten. The Council envisions a future where bypasses are expanded; channels are improved; and strong, well-maintained levees protect local communities—but also protect State interests in a more reliable water supply for California, and a protected and restored Delta ecosystem. These improvements will include new or expanded floodways and bypasses, maintaining and improving levees, and floodproofing new development. The Council envisions that rural areas and the Delta's legacy communities will also be protected from flood risks by careful land use planning that discourages urban development in flood-threatened areas. The Council envisions that local agencies will be better financed and protected through a locally controlled emergency response and flood protection district, with fee assessment authority. State funds for desired projects will be focused at State interests in the Delta, but some of that activity will protect local interests as well. Eliminating flood risks will be impossible, but prudent planning, reasonable land development, and improved flood management will significantly reduce risk, and serve the coequal goals of a more reliable water supply, and a protected and restored Delta ecosystem.

Delta Hazards Threaten Both Coequal Goals and the Delta as a Place

The risks that flooding, earthquakes, and other hazards pose to the Delta imperil California's water supplies and the health of the Delta ecosystem. The channels that convey water through the Delta to users in the Bay Area, San Joaquin Valley, or Southern California, and the islands that prevent saltwater intrusion into Delta water supplies depend upon levees for their preservation. Should the levees that protect these channels fail, the impacts on water supplies could be felt statewide. Improving these Delta levees is an investment in water supply reliability. Another way to reduce these risks is for areas that use Delta water to develop plans for possible interruption of these supplies in a catastrophic event, as recommended in Chapter 3. Integrating water supply and flood control efforts is also important to optimize the management of the multipurpose reservoirs that store water for the Central Valley Project (CVP), State Water Project (SWP), and other water users. For example, a potential benefit of wide flood bypasses leading to the Delta may be greater flexibility in these reservoir operations, creating new opportunities to manage water supplies or generate hydroelectric power.

The Delta levees also affect the health of the ecosystem. Many birds, such as waterfowl or sandhill cranes, thrive in areas that depend on levees for their management. In some locations, careful removal or breaching of levees may create new habitats that benefit fish and wildlife and the ecosystem. Setting levees back deliberately, when feasible, can create both more capacity for flood flows and more habitat for fish and wildlife. But unplanned levee failures often create weed-infested depths that harbor nonnative species rather than refuges for smelt, salmon, or other preferred species. Changes in the area protected by levees also alter water circulation through the Delta, changing the benefit of flows released to protect its ecosystem.

The Delta's residents, farms, and businesses also depend on its levees. They shape the Delta landscape, protecting its farms and communities from destruction. The levee system is the foundation on which the entire Delta economy is built, the Delta Protection Commission's (DPC's) *Economic Sustainability Plan* reports (DPC 2012). Delta residents built the levee system over generations, and they are keenly interested in its maintenance and improvement. (See sidebar, Delta Disaster Recalled, for an example of the consequences of levee failure.)

DELTA DISASTER RECALLED

On a moonlit Wednesday night in June 1972, the San Joaquin River flowed slowly after one of the driest winters on record. It gnawed at the Andrus Island levee 6 miles south of Isleton between Bruno's Yacht Harbor and Spindrift Resort, opening a small hole that grew rapidly. By the time sheriff's deputies arrived on scene shortly after 1 a.m., the river had carved a 100-foot break. By 3 a.m., water covered Highway 12. Shortly after sunrise, the breach had grown to 300 feet, and volunteers were hard at work on a 1.5-mile-long bow levee to protect Isleton.

The battle to save Isleton continued throughout the day, but a rising tide and waves created by 30- to 45-mile-per-hour Delta winds hampered efforts. Within a few hours, officials ordered the evacuation of 1,400 Isleton residents and an additional 1,500 residents of Andrus and Brannan islands. At 9:45 p.m. Thursday, the bow levee breached, and a wall of water rushed into the low-lying residential area of Isleton. Although the city's business district was spared, almost all of Andrus Island and portions of Brannan Island were flooded, in some places up to 20 feet deep.

Then-Governor Ronald Reagan declared the islands a disaster area and asked President Richard Nixon to do the same. Over the next 6 months, the levee was repaired, the 12,000-acre lake that had been Brannan and Andrus Islands was drained, and life began returning to normal. A full year after the levee break, however, more than one-third of the residents had neither moved back into their homes nor begun to rebuild.

Officials estimated that damages were $21.8 million, slightly more than half of that from crop loss and saltwater damage to farmland. The cost for levee repairs was put at $800,000, and $500,000 went to pump the 20 square miles of flooded land dry. More than $1.5 million in federal disaster relief was made available. No definitive cause was ever determined for the levee breach, and a subsequent court case absolved the State of liability (DWR 1973, Sacramento River Delta Historical Society 1996).

DP-361

Flood Risk in the Delta

The Delta is an inherently floodprone area. This section provides an overview of the causes and risks of floods in the Delta. The Sacramento and San Joaquin rivers collectively drain approximately 42,500 square miles of land. Before the Delta was modified by levees and other human structures, these rivers' natural flows overflowed the Delta's low-lying islands and floodplains for long periods each spring.

The biggest floods occurred when warm Pacific storms swept in from the west and southwest, picking up moisture over the ocean and causing torrential rains when intercepted by the mountains surrounding the Central Valley. The risks of flooding were increased when large amounts of sediment were discharged to Central Valley rivers during the Gold Rush, choking their channels and raising their beds above their natural levels and surrounding lands.

Today, flooding of the Delta's complex labyrinth of islands and waterways is prevented by its levees. This system of flood control is supplemented by the flood facilities of the Sacramento River and San Joaquin River flood control projects and multipurpose reservoirs such as Shasta, Folsom, and Millerton lakes and Lake Oroville on the Sacramento and San Joaquin rivers and their tributaries, which hold back floodwater and provide water supplies and other benefits described in Chapter 3.

Many Delta levees were initially constructed more than a century ago using primitive materials and equipment. History has shown that structural failures of the levee system occur as a result of extraordinary events, imperfect knowledge, and imperfect materials. Delta levees face potential threats such as large runoff events, extreme high tides, wind-generated waves, earthquakes, subsidence, and sea level rise. Individually, each of these threats is enough to cause serious concern; together, they represent the potential for catastrophic disruption of the Delta and its economic and ecological services.

A mass or even partial failure of the levee system would have real life-and-death impacts and property losses that could total billions of dollars. Delta flooding could interrupt the conveyance of water through the Delta for the SWP, the CVP, in-Delta users, the Contra Costa Water District, the cities of Antioch and Stockton, and others who depend on the Delta for reliable water supplies (see Chapter 3 for a discussion of water supply reliability). Levee failures could also damage key features of the Delta ecosystem, including managed wetlands in Suisun Marsh and habitats of wintering greater sandhill cranes at Staten Island and nearby tracts. Unplanned levee failure could also degrade water quality in the Delta, because tidewaters would flood into the bowl created by subsidence of Delta islands. These failures would draw saltwater from San Francisco Bay and pollute Delta water with flood debris, farm chemicals, and other pollutants.

Levee failures also could flood homes, farms, and businesses, including historic structures in the legacy communities, and interrupt recreation and tourism. As noted in Chapter 5, about 116,000 residential structures are located in the 100-year floodplain of the Delta, mostly near Sacramento, West Sacramento, and Stockton. Also, 8,000 residences are below mean higher high water (DWR 2008b). Serious consequences also could result from flood-related damage to critical infrastructure in the Delta, including radio, cellular telephone, and television transmission towers; electrical transmission lines, including Pacific Gas and Electric Company, Sacramento Municipal Utility District, and Western Area Power Administration lines; natural gas pipelines serving local gas fields and regional transmission systems; petroleum pipelines; three state highways; and three interstate highways (DWR 2011a).

In simplistic terms, the concept of flood risk can be described as the likelihood of a flood event occurring and the consequences of that event. To many, flood risk simply means the chance a storm event will overwhelm the flood control system to some extent. Figure 7-1 illustrates the variables, namely the probability of flooding and the financial consequences. However, there are many other causes of flood risk, and the consequences can be far more complicated than the immediate damage to property.

Understanding Delta Flood Risk

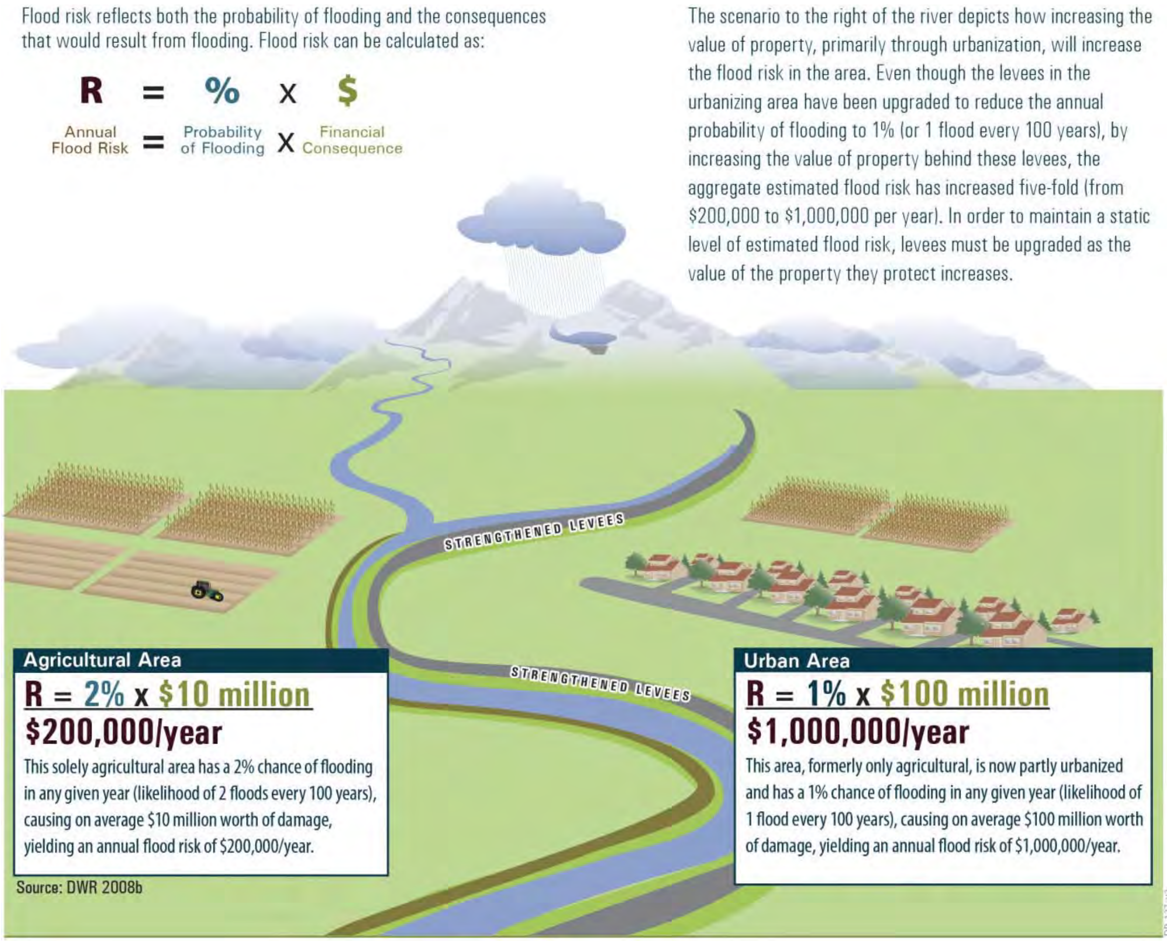


Figure 7-1

The best defense against these risks is first to better understand the Delta's flood hazards, and then manage and control those risks to the extent possible through public awareness; adequate emergency management planning; structural and nonstructural improvements, including enforcement of existing flood management regulations; and repairs, rehabilitation, and improvement of levees (including setback levees) and flood channels. Improving our understanding of risks through further evaluation and analysis of the flood control system and the assets it protects is essential to developing a rational, prioritized approach to flood management and public investment.

Floods

Flooding during winter storms that results in high water surface elevations and high winds has been a common cause of levee failures in the Delta. For example, the Sacramento River at Rio Vista may flow in excess of 300,000 cubic feet per second (cfs) during winter and early spring floods, 30 times typical late-summer flows of 10,000 cfs. Peak discharges place high stress on Delta levees and can create flood conditions, especially when coupled with high tides.

The likelihood of levee failures caused by high water is substantial, based on the historical performance of these levees over the last century. During the last century, there have been more than 140 levee failures and island inundations, most of which occurred during flood seasons (DWR 2005). High water in the Delta can overtop levees, as well as increase the hydrostatic pressure on levees and their foundations, causing instability and increasing the risk of failure due to through-levee and/or under-levee seepage. Most levee failures in the Delta have occurred during winter storms and related high-water conditions, often in conjunction with high tides and strong winds.

Earthquakes

The Delta's levees are also at risk from the active seismic zones west of the Delta, including the San Andreas and Hayward faults. Less active faults underlie the Delta. A strong earthquake could damage Delta levees because of the potential for liquefaction of levee embankments and foundations. Saturated levees composed of dredged materials in other parts of the country and the world have performed poorly during moderate to strong earthquake shaking (DWR 2009; Delta Stewardship Council Staff 2010a). If a levee failed during high flows or if a flood were to occur soon after an earthquake, the protected area could be inundated.

The risks of earthquakes causing levee breaches and island inundations in the Delta have long been recognized. A California Department of Water Resources (DWR) report begins:

> *There is a long history of levee failures in the Delta that have resulted in extensive economic damage, but no failures of Delta levees are known to be directly attributable to earthquakes. Even so, two factors indicate a possible bleak picture for the future of many Delta levees. First, no serious causative quakes have occurred on the nearby major faults since the San Francisco earthquake of 1906. Second, the Delta levees of today are vastly different than those in the 1906 Delta, which had limited size and extent. (DWR 1980)*

The DWR Delta Risk Management Strategy Phase 1 study evaluated the performance of Delta levees under various seismic threat scenarios, and analyzed potential consequences for water supply, water quality, ecosystem values, and public health and safety. The study concluded that a major earthquake of magnitude 6.7 or greater in the vicinity of the Delta Region has a 62 percent probability of occurring sometime between 2003 and 2032 (DWR 2009). Figure 7-2 illustrates a potential flood scenario in which a 6.5-magnitude earthquake causes a 20-island failure. Although the probabilistic nature of earthquake prediction makes it difficult to quantify the timing and magnitude of seismic threats, it is important to address the threats posed by earthquakes to the Delta levee system because of the potential adverse effects of such events.

High Tides and Sunny-day Risks

Even without an earthquake or flood, Delta levees can fail during high tides or even on sunny days. Generally, these failures may be the result of a combination of high tide, and pre-existing internal levee and foundation weaknesses caused by burrowing animals, internal erosion of the levee and foundation through time, and human interventions such as dredging or excavation at the toe of the levee (DWR 2008b). Examples of sunny-day failures include the Brannon Andrus Tract in 1972 and Upper Jones Tract in 2004. It is estimated that, based on current conditions, a sunny-day failure would occur once every 9 years on average (DWR and DFG 2008).

Other hazards that affect the performance of Delta levees include encroachments, penetrations, and burrowing animals. Encroachments such as structures or farming practices on or close to the levee; penetrations of the levee, such as culverts or pipelines; and burrows created by rodents, especially beavers, muskrats, and squirrels, can weaken the structural integrity of levees. Because of unregulated historical construction, levees also contain many hidden hazards. Active programs of inspection, oversight, and maintenance are essential to minimize these hazards.

Simulation of Delta Salinity after a 20-island Failure Caused by a Magnitude 6.5 Earthquake

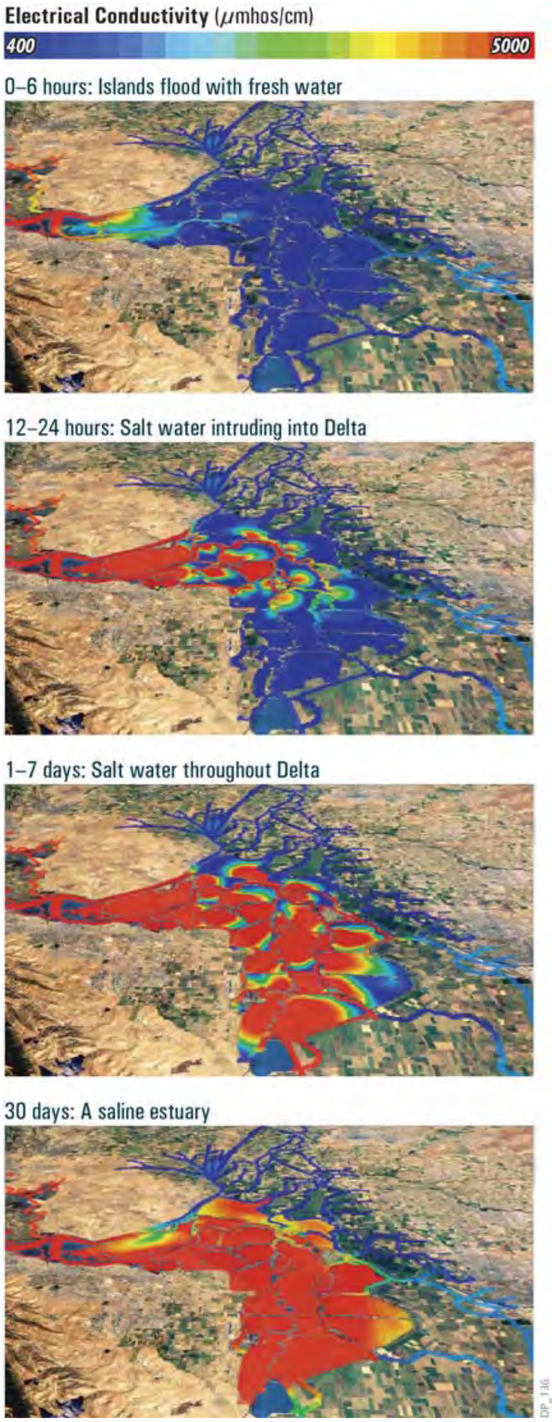


Figure 7-2 *Source: MWD 2010*

Land Subsidence

Because of the land subsidence described in Chapter 5, much of the central Delta is below sea level. Some islands are 12 to 15 feet below sea level, requiring levees 20 to 25 feet in height that act as dikes, holding back water continually rather than only during seasonal floods or extreme tides. As subsidence progresses, accommodation space increases, and levees must be continually maintained, strengthened, and periodically raised to support the increasing hydraulic stresses (Miller 2008, Mount and Twiss 2005). The hydraulic stress also can drive seepage through and under levees, and place levee foundations under more stress. The thinning of the peat soil layer also causes shallow or artesian groundwater conditions. More seepage onto islands will increase the drainage costs associated with additional pumping and decrease levee stability (Deverel and Leighton 2010).

Climate Change and Flood Risk

Climate change has major implications for the Delta, and especially for flood risk management. It is estimated that by the year 2100, sea levels may rise 31 to 69 inches (California Climate Action Team 2010, California Ocean Protection Council 2011), putting additional stress on levees and increasing their risk of failure. Projected changes in the timing and intensity of runoff may increase peak storm runoff and high-frequency flood events (DWR 2008c). Such floods could interrupt water conveyance through the Delta for those who depend on the Delta for water.

Additionally, scientific understanding of large-scale precipitation events is growing, as demonstrated by the ARkStorm scenarios being investigated by the U.S. Geological Survey, which indicate that massive storms and subsequent flooding have occurred and are likely to occur again (USGS 2011). Failure of significant parts of the Delta's flood management system may be unavoidable.

Planning for Flood Management

This section summarizes the current state of flood management planning for the Delta. To reduce the risk of flooding, Delta landowners, local governments, and State and federal agencies have planned and built an extensive levee system in the Delta, and significant flood control works upstream of the Delta. Other government flood control programs plan for emergency response in the event of floods, or help manage flood risks through land use planning, building standards, and flood insurance. The Delta Reform Act refers to these government-sponsored flood control programs in its provisions regarding covered actions (Water Code section 85057.5(a)(4)). The sidebar, What Is a Government-sponsored Flood Control Program?, highlights those programs referenced in statute; and proposed actions in the Delta that will have a significant impact on the implementation of one of these programs may be considered covered actions. Chapter 2 provides details about covered actions.

There are more than 1,000 miles of project and nonproject levees in the Delta and Suisun Marsh. Differences in how levees are classified can influence reports about their length and condition. Approximately 65 percent of the levees in the Delta and all levees in the Suisun Marsh are owned or maintained by local agencies or private owners and are not part of the flood control projects on the Sacramento or San Joaquin rivers. Most of these nonproject levees are maintained by local reclamation districts created and funded by landowners, initially for the purpose of draining ("reclaiming") Delta islands and tracts. The reclamation districts continue to maintain levees and other water control facilities today. These nonproject levees are defined in Water Code section 12980(e).

Many facilities throughout the Delta also drain rainfall runoff from land into Delta channels. Local cities and districts own and maintain urban storm drains in developed areas. Stockton, Sacramento, West Sacramento, Lathrop, Manteca, and Tracy are Delta cities with storm drainage facilities.

WHAT IS A GOVERNMENT-SPONSORED FLOOD CONTROL PROGRAM?

Any State or federal strategy, project, approval, funding, or other effort that is intended to reduce the likelihood and/or consequence of flooding of real property and/or improvements, including risks to people, property, and State interests in the Delta, that is carried out pursuant to applicable law, including, but not limited to, the following code:

- State Water Resources Law of 1945, Water Code section 12570 et seq.
- Sacramento-San Joaquin River Flood Control Projects (Flood Control Act of 1941, Public Law 77–228)
- Local Plans of Flood Protection (Water Code section 8201)
- Central Valley Flood Protection Plan (Water Code section 9600 et seq.)
- Subventions Program, Special Projects Program (Water Code section 12300 et seq.)
- Way Bill 1973 – Subventions Program, Special Projects Program (Water Code section 12980 et seq.)
- Central Valley Flood Protection Board Authority (California Code of Regulations, Title 23, Division 1)
- National Flood Insurance Program (National Flood Insurance Act of 1968, 42 United States Code 4001 et seq., Public Law 90-448)

DP-183

Most Delta islands have a network of agricultural drains and pumps to pump runoff into the Delta channels. Some Delta channels have been dredged to increase their capacity to carry floodwater and to obtain material for levee construction and maintenance.

The flood control projects on the Sacramento and San Joaquin rivers include approximately one-third of the Delta's levees. Known as "project levees," they begin on the left bank of the Sacramento River at Sherman Island, and line most of the riverbanks, as well as the Sacramento River Deep Water Ship Channel and some connecting waterways, north to Sacramento and beyond. The Delta Cross Channel's control gates are an important feature of this levee system, closing during high flows to keep the Sacramento River's floodwaters out of the central Delta. The flood control project also includes the Yolo Bypass, the broad, managed floodplain in Yolo County west of West Sacramento. The wide bypass, which is confined by project levees, draws floodwater through weirs above Sacramento to lower flood heights on the Sacramento River and its tributaries, discharging back to the Delta above Rio Vista. The Yolo Bypass floods about once every 3 years, between December and February. On the San Joaquin River, project levees line the riverbanks from Old River to Stockton. Figure 7-3 shows the locations of project and nonproject levees in the Delta.

Recent evaluations show that some of the flood control project facilities on the Sacramento and San Joaquin rivers are not adequate. Because the system was intended partly to flush Gold Rush-era sediment from rivers and channels, the project levees were often built close to the riverbanks, and are prone to erosion. Many of the system's channels have inadequate capacity to carry the flows for which they were designed, and many levees do not meet contemporary design standards (DWR 2011c).

The CVFPB, as part of its responsibility to oversee the flood control projects on the Sacramento and San Joaquin rivers, has adopted regulations to control encroachments on the project and some of the streams that flow into it. It also regulates encroachments within designated floodways, which are the channels of a river or other watercourse and the adjacent land areas that convey floodwaters (California Code of Regulations [CCR], Title 23, Division 1, Chapter 1, Article 2, Section 4). In the Delta, designated floodways include the Cosumnes River's floodplain and the confluence of the San Joaquin River and the Stanislaus River upstream from Paradise Cut.

Some levees are neither project levees nor nonproject levees. These "unattributed levees" include hundreds of miles of levees in Suisun Marsh and the Delta, and are not part of any State-financed flood control program. They also include some that are unmaintained along the perimeter of permanently flooded islands and no longer serve flood control or drainage purposes.

Multipurpose reservoirs in the Sacramento and San Joaquin river watersheds that play a role in California's water supply also serve critically important roles in managing floods that affect the Delta. The CVP's Shasta, Folsom, and Millerton lakes and New Melones Reservoir; the SWP's Lake Oroville; and other reservoirs are operated in accordance with flood control rules established by U.S. Army Corps of Engineers (USACE), reserving space to capture flood flows that can be released downstream gradually so that channels are not overwhelmed.

Many studies and planning efforts addressing flood management and emergency preparedness, response, and mitigation are under way, and will be considered by the Council for ongoing Delta flood risk management. These studies, efforts, and programs include the following:

- ***Central Valley Flood Protection Plan* (CVFPP).** This strategic plan for improving the flood control projects on the Sacramento and San Joaquin rivers recommends approaches for reducing flood risk and improving the flood control project, including expansion of the Yolo Bypass and construction of a new San Joaquin River Bypass at Paradise Cut (DWR 2011c) (see sidebar, Central Valley Flood Protection Plan).
- **DWR's FloodSAFE Initiative.** In 2006, DWR launched FloodSAFE California—a multifaceted initiative to improve public safety through integrated flood management.
- **DWR's Delta Levees Program.** This program encompasses both the Delta Levees Maintenance Subventions and Delta Levees Special Flood Control Projects programs, which provide State cost-share funding for Delta levee maintenance and upgrades.
- ***Sacramento-San Joaquin Delta Multi-Hazard Coordination Task Force Report.*** This report responds to Senate Bill (SB) 27 (Water Code section 12994.5), which called for the task force to make recommendations to the Governor about Delta multi-hazard emergency response and recovery issues.

- **USACE Delta Islands and Levees Feasibility Study, Long-Term Management Strategy for Dredging and Dredge Material Placement, Periodic Inspection Program, and Levee Safety Portfolio Risk Management System.** USACE has multiple programs addressing Delta-related flood management issues, including levee safety, levee integrity, and the beneficial reuse of dredged material.
- **CVP and SWP Reoperation Studies.** DWR's Forecast-coordinated Operations Program and Systems Reoperation Program address reservoir operational criteria, as noted in Chapter 3.

The Council will consider the findings of these studies and may incorporate them into future Delta Plan updates. The CVFPP and FloodSAFE include many concepts relevant to flood protection in the Delta. At the federal level, the National Committee on Levee Safety (2009) submitted a report to Congress that outlined the critical components of a National Levee Safety Program, and a high-level timeframe and steps for its creation. It is up to Congress to act on these recommendations, which will be monitored by the Council as they relate to the Delta Plan.

The CVFPB, DWR, and USACE each play unique and critical roles in Delta flood risk management. Because of this, the Council's role in facilitation, coordination, and integration of various agencies and other parties is of particular importance. Frequent, ongoing collaboration with other State, federal, and local agencies to improve communication and coordination is essential to meeting the Delta Plan's flood management objectives.

CENTRAL VALLEY FLOOD PROTECTION PLAN

The Central Valley Flood Protection Act of 2008 directed DWR to prepare the CVFPP. The CVFPP is a flood management planning effort that addresses flood risks and ecosystem restoration opportunities in an integrated manner. It specifically proposes a systemwide approach to flood management for the areas currently protected by facilities of the State Plan of Flood Control (SPFC). The CVFPP was adopted by the CVFPB in June 2012. It is expected that the CVFPP will be updated every 5 years thereafter.

The CVFPP proposes a systemwide approach to address the following issues:

- Physical improvements in the Sacramento and San Joaquin river basins
- Urban flood protection
- Small community flood protection
- Rural/Agricultural area flood protection
- System improvements
- Non-SPFC levees
- Ecosystem restoration opportunities
- Climate change considerations

The geographic scope of the CVFPP includes the portions of the Delta covered by the SPFC, including about 65 miles of urban, nonproject levees at Stockton; approximately two-thirds of Delta levees are not addressed in the CVFPP.

The effects of systemwide improvements directed by the CVFPP and the potential of redirected impacts to areas within the Delta will be monitored by the Council to ensure alignment with the coequal goals and the Delta Reform Act. Additionally, the Council may, at its discretion, incorporate those portions of the CVFPP into the Delta Plan to the extent that those portions promote the coequal goals (Water Code section 85350).

The 2012 CVFPP is only a descriptive document, highlighting a planning perspective at a reconnaissance level. Follow-on feasibility studies and project-specific development activities will be conducted over the next several years. The Council will continue to monitor and provide input to those activities to ensure that Delta flood risk issues are considered. Flood system improvement actions undertaken upstream of the Delta are of particular concern if not coupled with in-Delta actions that reduce overall systemwide flood risk.

DP_184

The Delta's Levees

The levees within the legal Delta protect approximately 740,000 acres of land. They define the Delta's physical characteristics; influence the reliability of its water supplies and its ecosystem health; and are critical to the Delta's residents, farms, businesses, cities, and legacy communities. Because many Delta levees protect land below sea level, they hold back water all day, year-round, rather than only during floods, and so are called "the hardest working levees" in America.

Levees in the Delta

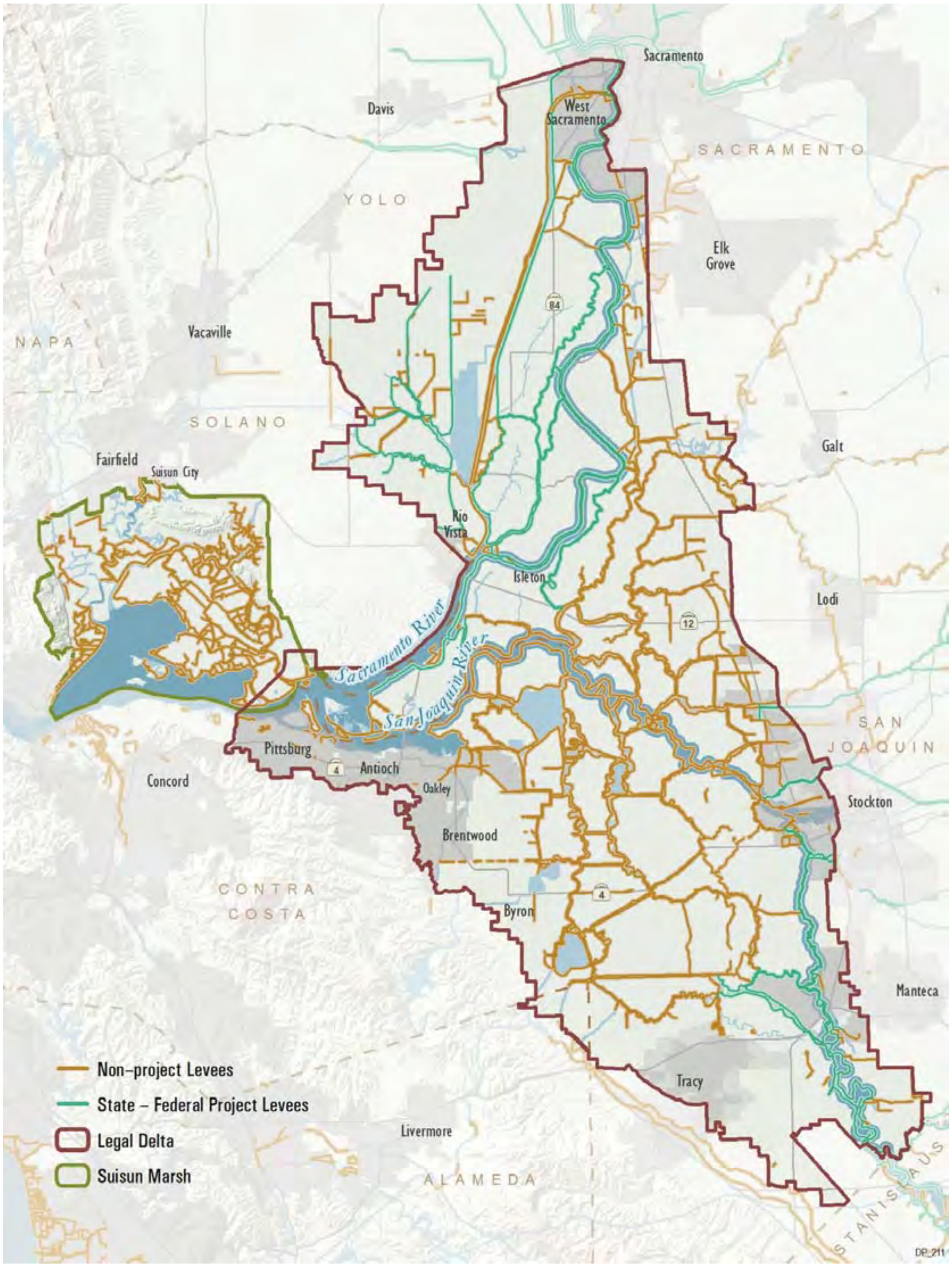


Figure 7-3 *Source: DWR 2011e*

Existing Levee Standards and Guidance

It is more important than ever that the Delta's levees are designed, constructed, and maintained to provide a level of flood risk reduction commensurate with the coequal goals and protection of the Delta's unique values as a place. Over the last few decades, State and federal agencies have developed guidelines and standards for levees. These standards establish minimum criteria for levee design and maintenance. The standards include (1) the level of flood protection California has prescribed for the Central Valley's urban areas, (2) whether sufficient protection is provided by the levees to exempt development financed with federally backed mortgages from requirements to obtain flood insurance, and (3) whether property and infrastructure protected by the levees (including the levees themselves) are eligible for assistance in the event of a catastrophic emergency, including aid from USACE to rehabilitate levees damaged in an emergency or for disaster assistance from the Federal Emergency Management Agency (FEMA).

Four levee standards and guidance applicable to the Delta are discussed below (and shown on Figure 7-4); they are ordered from highest to lowest level of flood protection:

- **DWR 200-year Urban Levee Protection (DWR - 200 Year):** This standard goes beyond criteria for levee height and geometric design to include requirements for freeboard, slope stability, seepage/underseepage, erosion, settlement, and seismic stability (DWR 2011b). It protects against a flood that has a 0.5 percent chance of being equaled or exceeded in any given year (a 200-year level of flood protection). This urban levee standard is the only levee standard that specifically links land uses to levee criteria. State law requires that by 2025, floodprone urban areas with over 10,000 residents must meet this 200-year flood protection standard (Government Code section 65865.5(a)(3)). Compliance likely will be achieved by upgrading levees to meet the 200-year design standard, under development by DWR. Sacramento, West Sacramento, and Stockton are planning levee improvements to attain this level of protection.

  Very few levees in the Delta meet this standard because most Delta levees do not protect urban areas. Under existing law, rural levees are not required to meet this standard.

- **FEMA 100-year (Base Flood) Protection (FEMA – 100 Year):** This "insurance" standard, often called the "1 percent annual chance flood" level of protection, provides criteria that levees must meet to protect against the flooding that is the basis for FEMA's flood insurance rate maps (44 Code of Federal Regulations 65.10). It is often used with established USACE criteria to prescribe requirements for levee freeboard, slope stability, seepage/underseepage, erosion, and settlement. The standard generally does not address seismic stability. In communities where levees provide this level of flood protection, new developments are not required to meet federal floodproofing standards and can obtain federally guaranteed mortgages without purchasing flood insurance.

  Few Delta levees outside of cities meet this standard, and many urban levees need improvement to meet it.

- **Public Law 84-99 (PL 84-99):** The PL 84-99 standard is a minimum requirement established by USACE for levees that participate in its Rehabilitation and Inspection Program (33 United States Code 701n) (69 Stat. 186). Twenty-five Delta reclamation districts, protecting about 31 percent of the legal Delta's land behind about 516 miles of levees, are at or above this standard, according to a recent report to the Council by DWR (DWR 2012). Delta islands or tracts that meet this standard are eligible for USACE funding for levee rehabilitation, island restoration after flooding, and emergency assistance, provided that the reclamation district is accepted into the USACE's program and passes a rigorous initial inspection and periodic follow-up inspections. Eligibility for PL 84-99 was formerly based primarily on levee geometry with minimum freeboard and maximum steepness of slopes. USACE's periodic

Levee Guidance

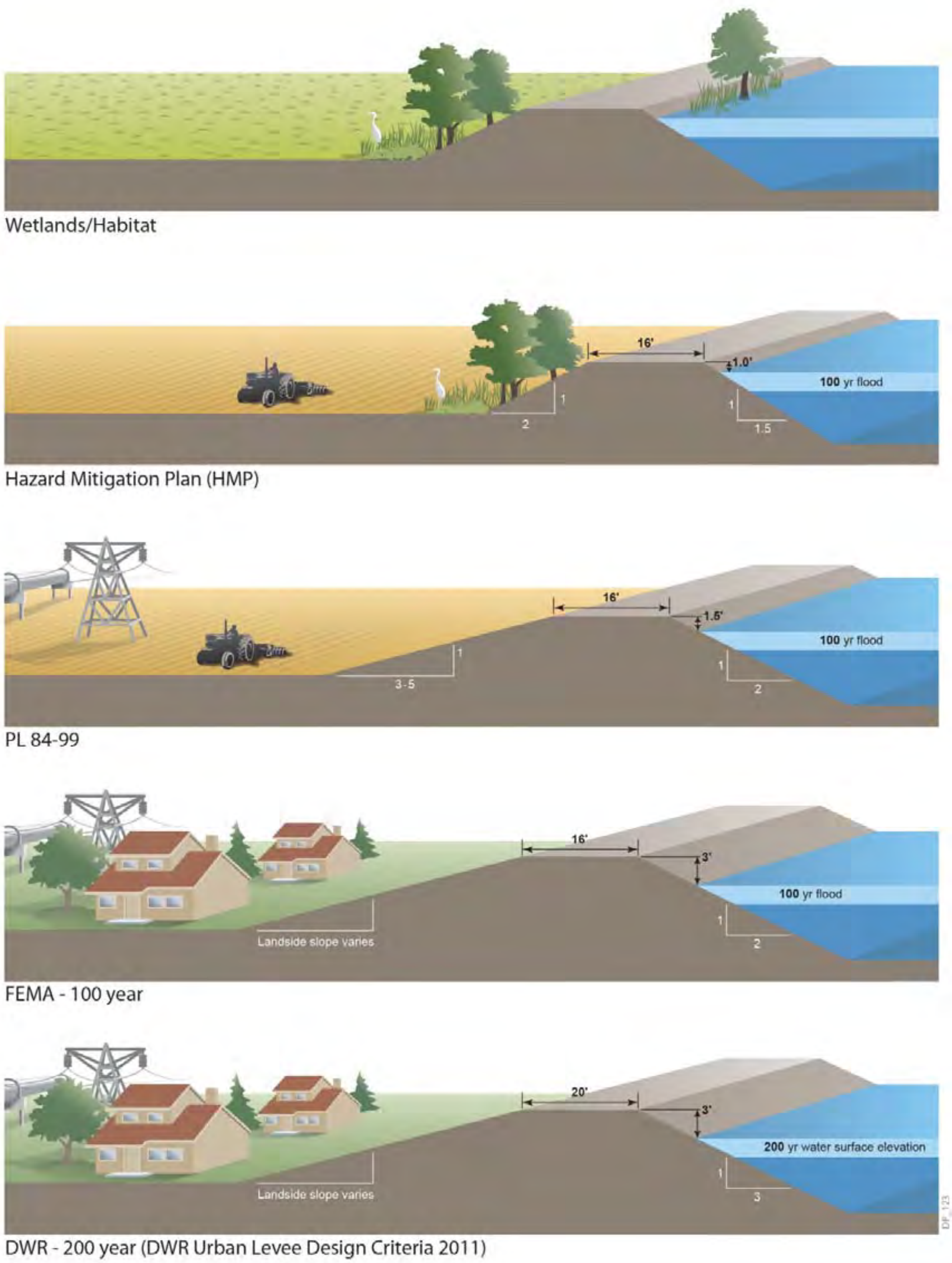


Figure 7-4 *Source: Adapted from Delta Vision Blue Ribbon Task Force 2008 and DWR 2011b*

inspection program incorporates other elements into eligibility, including presence of structure encroachments, vegetation, rodent control programs, and more. The standard for levee geometry implies a minimum levee height and a slope stability factor of safety, but is not associated with a level of protection (such as a 100-year flood) and does not address seismic stability. In 1987, USACE developed a Delta-specific standard based on the Delta's particular organic soils and levee foundation conditions. The CALFED Record of Decision set a goal of improving Delta levees to the PL 84-99 standard, as does the DPC Economic Sustainability Plan, but funding has been inadequate to attain this objective.

- **FEMA Hazard Mitigation Plan (HMP) Guidance:** FEMA, DWR, the California Office of Emergency Services (now the California Emergency Management Agency [Cal EMA]), and the Delta levee-maintaining agencies negotiated the HMP guidance to reduce the likelihood of repetitive flood damage to Delta levees and islands, so that FEMA disaster assistance would not be requested repetitively for the same islands after minor floods. Fifty-three of the Delta's reclamation districts, protecting over 47 percent of the legal Delta's acreage, fall below this standard, which 139 miles of Delta levees do not meet (DWR 2012). Local communities that do not meet the HMP guidance are not eligible for FEMA disaster reimbursement for flood fights or assistance if levees fail or islands flood. If even a portion of the levee around an island or tract does not meet the HMP guidance, assistance from FEMA to recover from levee damage is unavailable. Fifteen districts comply with this guidance, but are below the PL 84-99 standard. FEMA and Cal EMA have a memorandum of understanding, updated in 2010, that sets forth the requirements for FEMA public assistance funding for emergency flood fighting, emergency repair, permanent restoration, and/or replacement of eligible damaged nonproject levees within Delta reclamation districts (Cal EMA and FEMA 2010). The guidance is based on geometric criteria for the levees. The HMP guidance, negotiated between 1983 and 1987, was intended as an interim guidance, but has not been adjusted using subsequent or projected flood elevations.

No State standards currently address design criteria for flood protection of the state highways and interstate highways that traverse the Delta. Federal standards require that interstate highways must be protected from 50-year flood events to qualify for Federal Highway Administration funds (23 Code of Federal Regulations 650.115). Because most roads in the Delta were constructed before these standards were developed, they do not meet the standards. For example, sections of State Route 12 are 10 feet or more below sea level. A flood on the islands this highway traverses could interrupt transportation and trade, and put motorists at risk.

Levees and Ecosystem Function

Historically, most discussion of levees has emphasized reducing flood risks to life and property. However, habitat and ecosystem values and functions can provide multiple benefits, and must be considered in flood management planning and actions. For example, the CVFPP includes a conservation framework and strategy that outline how environmental elements can be integrated into flood management activities and provide an environmental guide for flood project planning. Setting levees back from the riverbank can expand flood conveyance capacity and reduce flood risk while providing ecosystem restoration and recreational opportunities (USACE 2002). Setback levees also allow opportunities for construction of an improved levee foundation and section using modern design and construction practices, thereby reducing risk of failure.

Much discussion has occurred on how to more effectively accommodate ecosystem function with the current levee system, highlighting the following issues (Healey and Mount 2007):

- Current levees tend to be narrow, with steep waterside slopes that provide little upland habitat value.

- Setback levees may provide habitat value and increased levee integrity.
- Levees can be used to promote specific habitat types (such as waterfowl habitat) by ensuring that some areas of freshwater marsh are sustained.
- Where lands are not heavily subsided, levees can allow for multiple land uses including habitat management and wildlife-friendly agriculture.
- Allowing levees to fail on deeply subsided islands would not generate any obvious ecological benefits.
- Subsidence reversal on deeply subsided islands would rely on levees to appropriately manage water levels during tule growth.

As management efforts in the Delta proceed, it will be important to consider ecosystem functions and their interactions with the levee system, as discussed in Chapter 4. An example where these interactions are already being debated is the USACE's current policy requiring removal of vegetation from levees. Scientific support for and against this policy is mixed. Concerns with maintaining woody vegetation on levees include difficulties with inspection and flood fighting, potential for root holes, and trees toppling from erosion. Other evidence, however, suggests that woody shrubs and small trees on levees enhance levee structural integrity while providing environmental benefits. A study on a channel levee along the Sacramento River concluded that roots reinforced the levee soil and increased shear resistance by providing increased stability against slope failures (Shields and Gray 1992). In either case, the widespread removal of vegetation from Delta levees could have significant adverse environmental impacts that are not well understood.

Floodplains and Channels

Floodplains and channels that provide the capacity to carry and store flood flows are critical for managing flood risks, and for overall Delta water management and ecosystem integrity. The CVFPB and FEMA both play roles in designating floodways and floodplains to accommodate flood flows.

The CVFPB regulates encroachment in floodplains by designating floodways in the Sacramento River and San Joaquin River drainages, including the Delta (Water Code section 8609). A "designated floodway" is the channel of the stream and that portion of the adjoining floodplain, as shown on Figure 7-5, reasonably required to provide for the passage of a specified flood. It may also be the floodway between existing levees as determined by the CVFPB.

The CVFPB regulates encroachments within designated floodways and regulated streams through its permitting authority. The encroachment permit process applies to all projects, existing and proposed (including habitat restoration projects), within State/federal flood control project levees, designated floodways, bypasses, and regulated streams (CCR, Title 23, Division 1). The CVFPB should be consulted prior to the consideration of any projects that may be in a designated floodway in the Delta. Appendix L includes a map of the CVFPB's jurisdictional areas in the Delta.

Additionally, under the National Flood Insurance Program, FEMA maps floodplains that have a 1 percent chance of flooding in any year (a 100-year flood). FEMA works with participating communities to regulate development within these floodplains according to federal regulations. No new construction, substantial improvements, or other development (including fill) may be permitted within specified flood zones on the community's Flood Insurance Rate Map unless it is demonstrated that the cumulative effect of the proposed development, when combined with all other existing and anticipated development, will not increase the water surface elevation of the base flood more than 1 foot at any point within the community.

In some flood channels and bypasses, dredging may have benefits because it increases channel capacity and also provides material that can be used for levee maintenance and other flood risk management activities. Because some

Conceptual Diagrams of Floodways

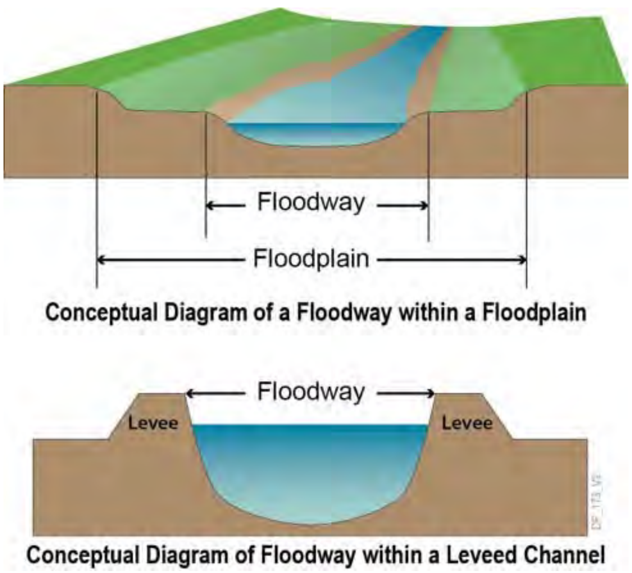


Figure 7-5 The floodway is the channel of the stream and that portion of the adjoining floodplain reasonably required to provide for the passage of a specified flood; it is also the floodway between existing levees as determined by the CVFPB or the Legislature.

Source: FEMA 2006

portions of the Delta are within a tidal pool and other areas are riverine, the efficacy of dredging must be addressed on a site-specific basis and cannot simply be considered useful on a Delta-wide basis.

The benefits and impacts of dredging Delta channels are being investigated by a consortium of federal and State agencies, including U.S. Environmental Protection Agency, USACE, DWR, and the Regional Water Quality Control Boards, under the Delta Dredged Sediment Long-Term Management Strategy (LTMS) Program. The LTMS is designed to improve operational efficiency and coordination of the collective and individual agency decision-making responsibilities resulting in approved dredging and dredged material management actions in the Delta. Approved dredging and dredged material management actions will take place in a manner that protects and enhances Delta water quality, identifies appropriate opportunities for the beneficial reuse of Delta sediments for levee rehabilitation and ecosystem restoration, and establishes safe disposal for materials that cannot be reused (USACE 2007).

Investment in Reducing Risk

Because the Delta's levees protect residents; agricultural land; water supplies; and energy, communications, and transportation facilities, the State has invested considerable funding in Delta levees over several decades through various legislative actions. Legislation sponsored by Senator Howard Way in 1973 established the Delta Levees Maintenance Subventions Program, SB 34 (1988) established the Delta Levees Special Flood Control Projects Program, and Assembly Bill 360 (1996) extended these two programs and initiated a requirement for net habitat enhancement. Bond measures passed since the late 1990s have provided sizeable but one-time funding for levee maintenance, repair, and improvements. Propositions 84 and 1E provided substantial public financing toward most of the recent Delta levee projects. An estimated $700 million of State taxpayer money has been spent by DWR on Delta levee maintenance and improvements since the Delta levee funding programs began in the 1970s. This includes $274 million of bond funds that are encumbered for future Delta levee projects. Funding to improve levees that protect urban and urbanizing areas within the Delta is currently provided by the State via the Early Implementation Program managed by DWR.

The Delta's project levees are authorized as part of the federal flood control project and so are eligible for federal funding (as well as the maintenance subventions mentioned below). The CVFPB serves as the nonfederal partner to USACE for the Delta's project levees.

State investments for nonproject levees in the legal Delta are distributed according to guidelines and criteria of the Delta Levees Maintenance Subventions Program or Delta Levees Special Flood Control Projects Program. These two programs provide State matching funds for maintaining and improving Delta levees. Local agencies in the legal Delta receive partial reimbursement for levee maintenance and rehabilitation from the State when funding is available. Currently, the State contributes up to 75 percent of qualifying costs for maintenance of many Delta levees. Local levee-maintaining agencies provide local cost-share matches, and both local and State efforts contribute to Delta flood risk reduction by maintaining continuous efforts to preserve Delta levees. It is often difficult for local agencies to raise funds for the local cost share of State and federal assistance programs. Funding assistance provided by the Delta Levees Maintenance Subventions Program is governed by guidelines developed by DWR and adopted by the CVFPB. State funds are not available for levee maintenance or improvement in most of Suisun Marsh.

Although the State has contributed the majority of costs for maintaining and improving Delta nonproject levees for many years, the concept of shared responsibility with local landowners is key to the long-term success of the Delta levee system. Neither the State nor the federal government is legally obligated to pay the full cost of Delta flood protection projects. The continued participation and financial support of local reclamation districts is essential. As noted in the Delta Reform Act's Section 85003(b), "Delta property ownership developed pursuant to the federal Swamp Land Act of 1850, and state legislation enacted in 1861, and as a result of the construction of levees to keep previously seasonal wetlands dry throughout the year. That property ownership, and the exercise of associated rights, continue to depend on the landowners' maintenance of those nonproject levees and do not include any right to state funding of levee maintenance or repair."

Prioritizing State Investment in Levees

The Delta Reform Act requires that State investments in Delta levees be prioritized to reduce risks to people, property, and State interests in the Delta (Water Code sections 85305(a) and 85306). Prioritizing investment is necessary to ensure that limited public funds are expended responsibly for improvements critical to State interests, rather than simply applying one objective to all Delta levees regardless of priority. These priorities, in combination with the Delta Reform Act directive that State agencies act consistently with the Delta Plan, will ensure that State spending on Delta levees reflects these priorities in the future. The Delta Reform Act provides that activities of the Council in determining priorities for State levee investments in Delta levees do not increase the State's liability for flood protection in the Delta or its watershed (Water Code section 85032(j)).

This Delta Plan outlines a process to prioritize State investments in levee operation, maintenance, and improvements in the Delta. It is also important to prioritize interim actions while longer-term guidelines are being established. Interim actions taken should consider and, where feasible, incorporate habitat and ecosystem values and enhancement in their development and implementation. This will allow for a more coordinated, effective approach to reducing Delta flood risk and prioritizing both immediate and long-term State investments. This approach will also take into account future actions that may be proposed through other planning efforts such as the CVFPP and Bay Delta Conservation Plan.

To effectively prioritize State investments in levees, a framework is needed to adequately assess Delta flood risk. This framework should include the following steps:

- Assess existing Delta levee conditions. Initially, a sufficient understanding of the current status of Delta levees is needed to establish baseline conditions against which future risk reduction efforts can be gauged. Because Delta levee conditions change, it is critical to conduct periodic assessments so that maintenance and improvement actions can be directed rationally. Assessment methods should be used that provide sufficient information to portray a reasonable snapshot of conditions.
- Develop an economics-based risk analysis for each Delta tract and island. This analysis must address several critical parameters, including life safety, private property, impacts on State water supply, critical infrastructure,

Delta water quality, ecosystem values, and systemwide integrity. Accepted risk analysis methods should be used, such as those developed by USACE (1996, 2006). This analysis could include "expected annual damage" assessments as a metric for analyzing flood risk. This approach, which integrates the likelihood and consequences of flooding, provides values that are useful for comparing flood risk at various locations and for ranking alternative levee projects.

- Conduct ongoing Delta flood risk analyses in an open manner for the public. Baseline and subsequent analytical efforts should always be conducted in manner open to scrutiny, with results being readily available for decision makers, interested parties, and the general public. Flood risk analyses will need to take into account future actions that may be proposed through other planning efforts such as the CVFPP and Bay Delta Conservation Plan.
- Develop an updated understanding of Delta hydrology. An updated understanding of water surface elevations in the Delta is critical for levee design purposes and should be addressed.

The approach must be based on sound scientific and engineering principles, and incorporate appropriate economic and hydrologic data.

As these long-term priorities for State investments in levee operation, maintenance, and improvements are developed, State funds for Delta levee projects should focus on the interim priorities set forth in RR P1, including the following actions:

- Provide a 200-year level of flood protection for existing urban and adjacent urbanizing areas (Water Code section 9600 et seq.).
- Improve the levees that protect aqueducts crossing the Delta and the freshwater pathway to Clifton Court Forebay, as depicted on Figure 7-6, to improve the reliability of these water supplies.
- Improve other Delta levees not specifically planned for ecosystem restoration to the FEMA HMP guidance level to ensure that the Delta's reclamation districts are eligible for public funding for emergency flood fighting, emergency repair, permanent restoration, and/or replacement of eligible damaged nonproject levees.
- Continue to fund and implement the Delta Levees Maintenance Subventions Program to maintain Delta levees.

In addition, the Delta Plan proposes creating a regional agency to assist with the planning, implementation, and financing of Delta flood risk reduction activities (see RR R2). Local levee-maintaining agencies have managed the financing and ongoing maintenance, rehabilitation, and repair of Delta levees, and have improved the levels of levee integrity, reducing overall Delta flood risk. Although the State has provided financial assistance over several decades, these programs have been funded primarily through State general obligation bonds, which face an uncertain future. The unencumbered bond funds that remain available for Delta levee projects total only $123 million.

An alternative funding mechanism could provide a more stable, long-term approach to funding in which local participation by all beneficiaries of flood risk management is more broadly incorporated. A regional flood risk management district with fee assessment authority could address a variety of Delta flood risk-related activities, including levee maintenance and improvements; regional flood management planning; flood facilities inspections; data collection; risk notification; and emergency preparedness planning, response, and mitigation. A regional flood risk management district could complement reclamation district activities. Because two ballot measures, Propositions 218 (1996) and 26 (2010) (discussed in Chapter 8), have raised the approval thresholds for new fees and taxes, the proposed regional assessment district will need to be broadly supported.

Delta Flood Management Facilities

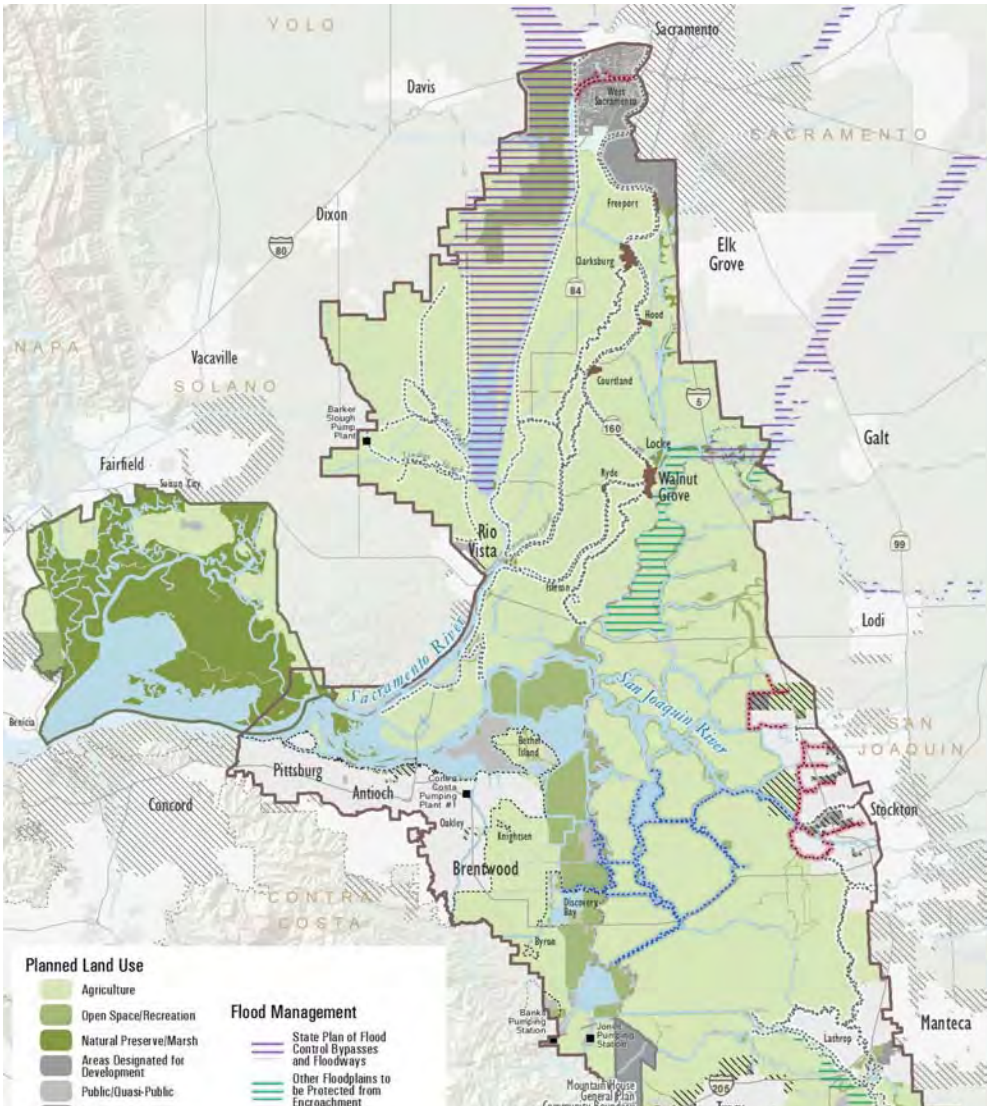


Figure 7-6 The map shows land uses designated by city and county general plans. Within cities' spheres of influences, the map shows land use designations proposed in city general plans, where available. In cases where cities have not proposed land uses within their spheres of influence, the map shows land uses designated by county general plans.

Sources: City of Benicia 2003, Contra Costa County 2008, Contra Costa County 2010, DWR 2011b, DWR 2011c, DWR 2011d, City of Fairfield 2008, Jones & Stokes 2007, City of Lathrop 2012, City of Manteca 2012, Mountain House Community Services District 2008, City of Rio Vista 2001, SACOG 2009, City of Sacramento 2008, Sacramento County 2011, Sacramento County 2012, Sacramento County 2013, San Joaquin County 2008a, San Joaquin County 2008b, Solano County 2008a, Solano County 2008b, South Delta Levee Protection and Channel Maintenance Authority 2011, City of Stockton 2011a, City of Stockton 2011b, City of Suisun City 2011, City of Tracy 2011a, City of Tracy 2011b, City of West Sacramento 2010, Yolo County 2010a, Yolo County 2010b.

Planning for Floodplain Land Use

The most important step in reducing risk to people in the Delta is to stop putting more people at risk behind levees that do not meet minimum modern standards for flood protection. Actions that increase the demand for higher public spending on flood risk reduction and exacerbate flood risk (for example, urbanizing floodprone areas) should be discouraged.

The DPC *Land Use and Resource Management Plan for the Primary Zone of the Delta* also includes important policies to limit development in floodprone areas of the Primary Zone:

> *Local governments shall carefully and prudently carry out their responsibilities to regulate new construction within flood hazard areas to protect public health, safety, and welfare. These responsibilities shall be carried out consistent with applicable regulations concerning the Delta, as well as the statutory language contained in the Delta Protection Act of 1992. Increased flood protection shall not result in residential designations or densities beyond those allowed under zoning and general plan designations in place on January 1, 1992, for lands in the Primary Zone. (DPC 2010)*

As noted in Chapter 5, the legacy community of Bethel Island warrants a special note because of its flood hazards. About 2,100 people reside on the island in about 1,300 residences concentrated on the south central shoreline and four mobile home parks. The island, which is below sea level, is surrounded by approximately 15 miles of levees, limiting the drainage of floodwaters in the event of a levee breach. A single road, Bethel Island Road, links the island to the mainland at the city of Oakley, complicating emergency response or evacuation in the event of flooding. Because developments on Bethel Island are proposed to be served by the Bethel Island Municipal Improvement District or other adjacent public services, the entire island is within the urban limit line adopted by Contra Costa voters in 2006. The high flood risks on the island and the restricted evacuation opportunities, however, indicate the island has greater hazards to lives and property than the Delta's other areas designated for development. For this reason, it is not excluded from the Delta Plan policy prohibiting new subdivisions unless adequate flood protection is provided. This is consistent with provisions of the Contra Costa County General Plan, which require that development other than a single home on existing parcels await resolution of several issues, including improvement of the community's public services, levees, and emergency evacuation routes.

As described in Chapter 5, urban residential, commercial, and industrial uses should be located in cities, other urban areas, and their spheres of influence, where strong levees can be provided, rather than in rural lands protected only by nonproject levees. Outside of these urban and urbanizing areas and the legacy communities, the Delta Plan prohibits major subdivisions of five or more parcels where 200-year flood protection is not available. Recognizing legacy community needs for incidental growth to maintain their unique cultural values, development within community boundaries should continue consistent with existing general plans, and federal and local flood protection laws. Appendix B provides maps of Delta community boundaries. Maintaining most of the Delta in rural, agricultural land use, as described in Chapter 5, complements policies that reduce the number of properties and the population exposed to high flood risks.

Finally, the participation of Delta counties and cities in the National Flood Insurance Program brings with it a requirement that all residential, commercial, agricultural, and industrial buildings comply with FEMA floodproofing standards, including elevating structure ground floors above the 100-year flood elevation. Examples of floodproofing are shown on Figure 7-7.

Examples of Floodproofing

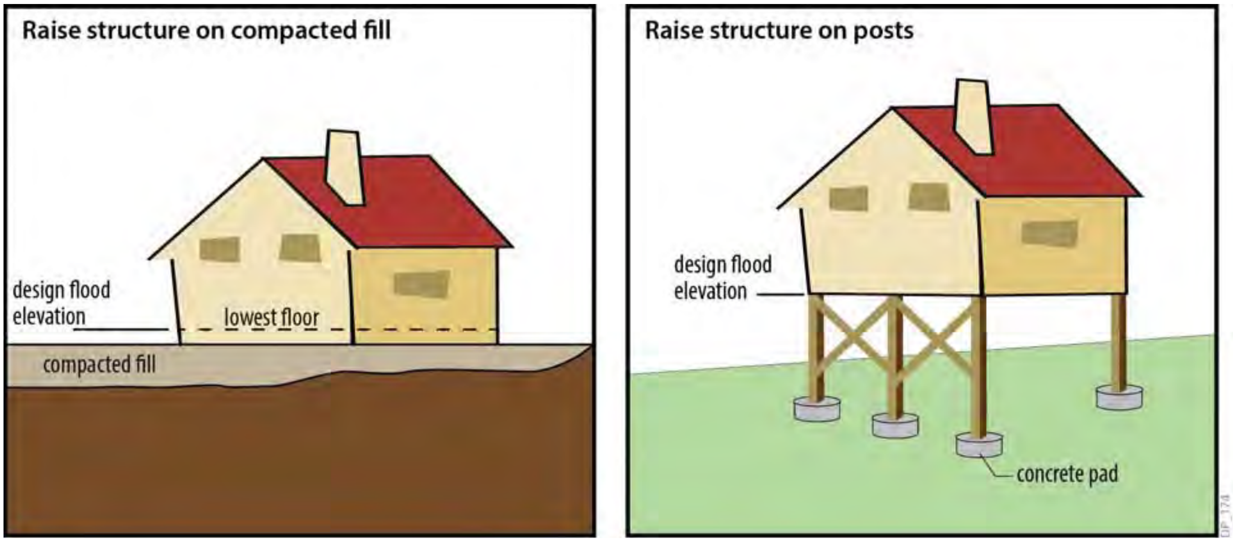


Figure 7-7

Floodproofing in accordance with the National Flood Insurance Program can be achieved through several methods. The illustration on the left shows an example of floodproofing by constructing the lowest floor within a structure above the design flood elevation. The illustration on the right shows floodproofing by raising the bottom of the structure above the design flood elevation.

Source: FEMA 1994; FEMA 2001

Emergency Preparedness and Response

Even with the best-engineered levees, channels, and floodways, a residual risk from flooding will always remain; flood risk can never be eliminated. Although investment in flood protection infrastructure can considerably reduce the likelihood of a catastrophic levee failure, failures are inevitable and will require well-coordinated and carefully developed emergency response efforts. To reduce response time and optimize effectiveness of response efforts, such plans need to leverage the unique capabilities of each agency with a mission in the Delta. This section provides an overview of the agencies and planning involved in emergency preparedness and response in the Delta.

Responsibilities for preparing for, declaring, and responding to flood emergencies are distributed among local, State, and federal agencies. Federal agencies with authority include USACE and FEMA. In California, State and local responsibilities fall to county offices of emergency services, local reclamation districts, Cal EMA, and DWR. In a Delta flood emergency, the response efforts by local and State emergency management professionals are guided by California's Standardized Emergency Management System (SEMS). SEMS was established by Government Code section 8607(a), and provides for effective management of multiagency and multijurisdictional emergencies in California, including flood emergencies. This system consists of five organizational levels, which are activated as necessary: (1) field response, (2) local government, (3) operational area, (4) regional, and (5) State. These levels are activated stepwise as the events warrant additional response and resources, meaning that each level of emergency responder contacts the next level above them should they deem the emergency beyond their capabilities to control. Federal resources are called upon if State resources are exhausted or additional assistance is needed. SEMS incorporates the functions and principles of the Incident Command System, the Master Mutual Aid Agreement, existing mutual aid systems, the operational area concept, and multiagency or interagency coordination. A detailed discussion of SEMS can be found in Cal EMA SEMS Guidelines (Cal EMA 2009). Local governments must use SEMS to be eligible for funding of their response-related personnel costs under State disaster assistance programs.

At the State level, Cal EMA's *California Emergency Plan* is the current guiding plan for all State emergencies. The California Emergency Plan incorporates and complies with the principles and requirements found in federal and State laws, regulations, and guidelines. Cal EMA typically defers to DWR for emergency management during floods. DWR emergency flood management actions are guided by its 2007 *Interim Flood Emergency Operations Plan*. DWR is in the process of developing its Delta Flood Emergency Preparedness Response and Recovery Program (EPRRP), which will be the overall guiding flood emergency management program for DWR activities for project and nonproject levees in the Delta. The Delta Flood EPRRP consists of three components: (1) the plan for flood emergency preparedness, response, and recovery actions in the Delta; (2) multiagency plan coordination, which coordinates DWR's plan with the plans of other Delta flood response agencies; and (3) response facilities implementation, which includes the development of flood emergency response facilities in the Delta.

At the federal level, USACE has a standing All-Hazards Emergency Response Plan and standing contracts for emergency response work in the Delta region, and is ready to assist the State, as requested through PL 84-99. These existing plans and procedures are considered in DWR's flood emergency operations plans and are a critical part of the Delta Flood EPRRP Plan. FEMA is responsible for coordinating the response of several federal agencies to a large natural disaster that overwhelms the resources of State and local authorities. The primary duty of FEMA is to ensure services to disaster victims through operational planning and integrated preparedness measures.

Following a flood disaster, various federal programs can provide disaster assistance. USACE has specific criteria concerning eligibility for assistance under PL 84-99. FEMA's HMP criteria must be met to be eligible for its assistance (Delta Stewardship Council Staff 2010b).

To further address emergency preparedness and response issues in the Delta, the Legislature passed SB 27 (Water Code section 12994.5) to develop and implement multi-hazard preparedness and response strategies for the Delta. This legislation required the Office of Emergency Services (now Cal EMA) to establish the Sacramento-San Joaquin Delta Multi-Hazard Coordination Task Force. Led by Cal EMA, the task force consisted of representatives from the DPC, DWR, and representatives of the five Delta counties. The task force was directed to do the following:

- Make recommendations to the Secretary of Cal EMA relating to the creation of an interagency unified command system organizational framework, in accordance with the guidelines of the National Incident Management System and SEMS.
- Coordinate the development of a draft emergency preparedness and response strategy for the Delta region for submission to the Secretary of Cal EMA. Where possible, the strategy shall use existing interagency plans and planning processes of the involved jurisdictions and agencies that are members of the DPC.
- Develop and conduct all-hazard emergency response exercises and training in the Delta that are designed to test or facilitate implementation of regional coordination protocols.

The recommendations being prepared by the task force will likely play an important role in planning efforts for the Delta, and will be considered in the Delta Plan. When this Delta Plan was written, the task force recommendations had been approved by the Secretary of Cal EMA and forwarded to the Governor.

San Joaquin County has developed flood contingency maps and urban evacuation maps as part of its coordinated flood emergency planning efforts. These maps and plans could be used as an example by other Delta counties, and State and federal agencies to prepare a Delta-wide emergency response plan.

Liability Concerns

USACE and other federal agencies are generally afforded some immunity from liability for damages from flood events under the concept of sovereign immunity and provisions of the Flood Control Act of 1928 (33 United States Code section 702c). Congress provided immunity to federal agencies for some but not all tort damages. However, this immunity does not apply to nonfederal agencies.

As the risks of levee failure and corresponding damage increase, California's courts have generally exposed public agencies, and the State specifically, to significant financial liability for flood damages (DWR 2005). The most notable recent court decision on flood liability was the California Court of Appeal decision in *Paterno v. State of California* (2003) (113 Cal. App. 4th 998). The court found the State was liable for damages caused by the failure of a project levee on the Yuba River that the State did not design, build, or even directly maintain. This decision makes it possible that the State will ultimately be held responsible for the structural integrity of much of the federal flood control system in the Delta and Central Valley. The *Paterno v. State of California* decision will ultimately cost State taxpayers approximately $464 million in awarded damages.

In *Arreola v. County of Monterey* (2002) (99 Cal. App. 4th 722), the court held local agencies and the California Department of Transportation (Caltrans) liable for 1995 flood damages to property owners that resulted from a failure to properly maintain levees of the Pajaro River project.

The California *Draft FloodSAFE Strategic Plan* states, "Local communities are responsible for land use decisions, but generally have not been found liable for failure of the flood protection system. Continued local actions to approve development within floodplains may increase flood risk, even if levees and other flood protection improvements are made. This creates liability issues which the State is concerned about. Legislation passed in 2007 addresses the need to connect land use planning with diligent and factual consideration of flood risks for areas of proposed development" (DWR 2008a).

In 2007, the Legislature amended the Water Code to address local community liability for approving development in floodprone areas. It provides that "a city or county may be required to contribute its fair and reasonable share of the property damage caused by a flood to the extent that the city or county has increased the state's exposure to liability for property damage by unreasonably approving new development in a previously undeveloped area that is protected by a state flood control project" (Water Code sections 8307(a) and (b)).

Ultimately, however, it is important to note that the State does not own, operate, control, or maintain nonproject levees, and does not have authority to do so. The Delta levee subventions program grants financial assistance to local reclamation districts for their levees. The State conducts evaluations to make sure subventions program funds have been spent appropriately, but not to ensure the quality of the work or the stability or structural integrity of nonproject levees. Rather, the nonproject levees are the sole responsibility of the reclamation districts, and the State is not liable for damages caused by their failure.

POLICIES AND RECOMMENDATIONS

These policies and recommendations are based on the Council's core strategies for reducing flood risks in the Delta, which are:

- Improve emergency preparedness and response
- Finance and implement flood management activities
- Prioritize flood management investment
- Improve residential flood protection
- Protect and expand floodways, floodplains, and bypasses
- Integrate Delta levees and ecosystem function
- Limit liability

Reducing flood risks also relies on locating urban development in the Delta's cities where levees are stronger, as discussed in Chapter 5, and retaining rural lands for agriculture, so that development in the most floodprone areas is minimized.

Improve Emergency Preparedness and Response

To effectively and reliably reduce risks to people, property, and State interests in the Delta, a multifaceted strategy of coordinated emergency preparedness, appropriate land use planning, and prioritized investment in flood protection infrastructure is necessary (Water Code sections 85305(a) and 85306). Federal, State, and local governments—and Californians—must be prepared for a variety of emergency situations.

The recommendations prepared by the Sacramento-San Joaquin Delta Multi-Hazard Coordination Task Force will likely play an important role in planning efforts for the Delta, and will be considered by the Council for incorporation in future updates of the Delta Plan.

Problem Statement

Levee failures and flooding can and will place human life and property in danger, and can have potentially significant implications for the State's water supply and infrastructure, and the health of the Delta ecosystem. Appropriate emergency preparedness and response planning and implementation activities need to be initiated.

Policies

No policies with regulatory effect are included in this section.

Recommendations

RR R1. Implement Emergency Preparedness and Response

The following actions should be taken by January 1, 2014, to promote effective emergency preparedness and response in the Delta:

- *Responsible local, State, and federal agencies with emergency response authority should consider and implement the recommendations of the Sacramento-San Joaquin Delta Multi-Hazard Coordination Task Force (Water Code section 12994.5). Such actions should support the development of a regional response system for the Delta.*
- *In consultation with local agencies, the California Department of Water Resources should expand its emergency stockpiles to make them regional in nature and usable by a larger number of agencies in accordance with California Department of Water Resources' plans and procedures. The California Department of Water Resources, as a part of this plan, should evaluate the potential of creating stored material sites by "over-reinforcing" west Delta levees.*
- *Local levee-maintaining agencies should consider developing their own emergency action plans, and stockpiling rock and flood-fighting materials.*
- *State and local agencies, and regulated utilities that own and/or operate infrastructure in the Delta should prepare coordinated emergency response plans to protect the infrastructure from long-term outages resulting from failures of the Delta levees. The emergency procedures should consider methods that also would protect Delta land use and ecosystem.*

Finance and Implement Local Flood Management Activities

The responsibility for securing funding for Delta levee maintenance, repairs, and improvements lies with the numerous local levee-maintaining agencies (primarily reclamation districts). Funding is generated through property assessments of local landowners and also is provided by the State under programs administered by DWR (the Delta Levees Special Flood Control Projects and Delta Levees Maintenance Subventions programs). These programs provide State matching funds for addressing Delta flood risk; however, many other entities that benefit from flood risk management are not assessed, nor do they contribute to maintenance and upkeep of Delta levees, including owners of regional infrastructure that crosses the Delta. The duty of providing for Delta flood risk management should be borne by all entities benefitting from these actions, and an equitable methodology of defining and apportioning assessments should be developed and implemented.

Local levee-maintaining agencies have managed the financing and ongoing maintenance, rehabilitation, and repair of Delta levees, and have improved the levels of levee integrity, reducing overall Delta flood risk. Although financial assistance has been provided by the State over several decades, these programs have most recently been funded exclusively through State general obligation bond financing, which faces an uncertain future. The development of an alternative funding mechanism and authority would provide for a more stable, long-term funding approach in which local participation by all beneficiaries of flood risk management is more broadly incorporated. Propositions 218 (1996) and 26 (2010) raised the approval thresholds for new fees and taxes; these thresholds may make it more difficult for a proposed regional assessment district to gain revenue authority.

The establishment of a regional flood risk management district with fee assessment authority could address a variety of Delta flood risk-related activities, including levee maintenance and improvements; regional flood management planning; flood facilities inspections; data collection; risk notification; and emergency preparedness planning, response, and mitigation. Establishing a more centralized and responsive entity could provide a mechanism for addressing issues at the individual district level and for the Delta region overall for the long term.

Problem Statement

No mechanism exists for ensuring that costs of levee maintenance are borne by all beneficiaries. Current financing of levee operations and maintenance is not well coordinated, and future funding sources are uncertain. Financing of local levee operations, maintenance, emergency preparedness and response, and related data collection and reporting efforts would benefit from greater coordination and integration.

Policies

No policies with regulatory effect are included in this section.

Recommendations

RR R2. Finance Local Flood Management Activities

The Legislature should create a Delta Flood Risk Management Assessment District with fee assessment authority (including over State infrastructure) to provide adequate flood control protection and emergency response for the regional benefit of all beneficiaries, including landowners, infrastructure owners, and other entities that benefit from the maintenance and improvement of Delta levees, such as water users who rely on the levees to protect water quality.

This district should be authorized to:

- *Identify and assess all beneficiaries of Delta flood protection facilities.*
- *Develop, fund, and implement a regional plan of flood management for both project and nonproject levees of the Delta, including the maintenance and improvement of levees, in cooperation with the existing reclamation districts, cities, counties, and owners of infrastructure and other interests protected by the levees.*
- *Require local levee-maintaining agencies to conduct annual levee inspections per the California Department of Water Resources subventions program guidelines, and update levee improvement plans every 5 years.*
- *Participate in the collection of data and information necessary for the prioritization of State investments in Delta levees consistent with RR P1.*
- *Notify residents and landowners of flood risk, personal safety information, and available systems for obtaining emergency information before and during a disaster on an annual basis.*
- *Potentially implement the recommendations of the Sacramento-San Joaquin Delta Multi-Hazard Coordination Task Force (Water Code section 12994.5) in conjunction with local, State, and federal agencies, and maintain the resulting regional response system and components and procedures on behalf of SEMS jurisdictions (reclamation district, city, county, and State) that would jointly implement the regional system in response to a disaster event.*
- *Identify and assess critical water supply corridor levee operations, maintenance, and improvements.*

RR R3. Fund Actions to Protect Infrastructure from Flooding and Other Natural Disasters

- *The California Public Utilities Commission should immediately commence formal hearings to impose a reasonable fee for flood and disaster prevention on regulated privately owned utilities with facilities located in the Delta. Publicly owned utilities should also be encouraged to develop similar fees. The California Public Utilities Commission, in consultation with the Delta Stewardship Council, the California Department of Water Resources, and the Delta Protection Commission, should allocate these funds among State and local emergency response and flood protection entities in the Delta. If a new regional flood management agency is established by law, a portion of the local share would be allocated to that agency.*
- *The California Public Utilities Commission should direct all regulated public utilities in their jurisdiction to immediately take steps to protect their facilities in the Delta from the consequences of a catastrophic failure of levees in the Delta, to minimize the impact on the State's economy.*
- *The Governor, by Executive Order, should direct State agencies with projects or infrastructure in the Delta to set aside a reasonable amount of funding to pay for flood protection and disaster prevention. The local share of these funds should be allocated as described above.*

Prioritize Flood Management Investment

A method is needed for prioritizing State funds for use in operating, maintaining, and improving Delta levees with a systemwide approach. Although the State has expended millions of dollars since the early 1970s on Delta levees, almost half of the Delta's acreage is not protected by levees that meet the HMP guidance today. Efforts by landowners, reclamation districts, and other parties using local resources to perform levee upgrades, beyond the standards that may be funded by the State, are encouraged and would be consistent with the goal of reducing Delta flood risk. The Delta Reform Act provides that activities of the Council in determining priorities for State investments in Delta levees do not increase the State's liability for flood protection in the Delta or its watershed.

Problem Statement

The Delta Reform Act (Water Code section 85306) requires the Delta Plan to recommend priorities for State investments in Delta levees, including project and nonproject levees. Currently, no comprehensive method exists to prioritize State investments in Delta levee operations, maintenance, and improvement projects. Without a prioritization methodology, the apportionment of public resources into levees may not occur in a manner that reflects a broader, long-term approach.

Policies

RR P1. Prioritization of State Investments in Delta Levees and Risk Reduction

(a) Prior to the completion and adoption of the updated priorities developed pursuant to Water Code section 85306, the interim priorities listed below shall, where applicable and to the extent permitted by law, guide discretionary State investments in Delta flood risk management. Key priorities for interim funding include emergency preparedness, response, and recovery as described in paragraph (1), as well as Delta levees funding as described in paragraph (2).

(1) Delta Emergency Preparedness, Response, and Recovery: Develop and implement appropriate emergency preparedness, response, and recovery strategies, including those developed by the Delta Multi-Hazard Task Force pursuant to Water Code section 12994.5.

(2) Delta Levees Funding: The priorities shown in the following table are meant to guide budget and funding allocation strategies for levee improvements. The goals for funding priorities are all important, and it is expected that over time, the California Department of Water Resources must balance achievement of those goals. Except on islands planned for ecosystem restoration, improvement of nonproject Delta levees to the Hazard Mitigation Plan (HMP) standard may be funded without justification of the benefits. Improvements to a standard above HMP, such as that set by the U.S. Army Corps of Engineers under Public Law 84-99, may be funded as befits the benefits to be provided, consistent with the California Department of Water Resources' current practices and any future adopted investment strategy.

Priorities for State Investment in Delta Integrated Flood Management Categories of Benefit Analysis

Goals	Localized Flood Protection	Levee Network	Ecosystem Conservation
1	Protect existing urban and adjacent urbanizing areas by providing 200-year flood protection.	Protect water quality and water supply conveyance in the Delta, especially levees that protect freshwater aqueducts and the primary channels that carry fresh water through the Delta.	Protect existing and provide for a net increase in channel-margin habitat.
2	Protect small communities and critical infrastructure of statewide importance (located outside of urban areas).	Protect floodwater conveyance in and through the Delta to a level consistent with the State Plan of Flood Control for project levees.	Protect existing and provide for net enhancement of floodplain habitat.
3	Protect agriculture and local working landscapes.	Protect cultural, historic, aesthetic, and recreational resources (Delta as Place).	Protect existing and provide for net enhancement of wetlands.

(b) For purposes of Water Code section 85057.5(a)(3) and section 5001(j)(1)(E) of this Chapter, this policy covers a proposed action that involves discretionary State investments in Delta flood risk management, including levee operations, maintenance, and improvements. Nothing in this policy establishes or otherwise changes existing levee standards.

23 CCR Section 5012
NOTE: Authority cited: Section 85210(i), Water Code.
Reference: Sections 85020, 85300, 85305, and 85306, Water Code.

Recommendations

RR R4. Actions for the Prioritization of State Investments in Delta Levees

The Delta Stewardship Council, in consultation with the California Department of Water Resources, the Central Valley Flood Protection Board, the Delta Protection Commission, local agencies, and the California Water Commission, should develop funding priorities for State investments in Delta levees by January 1, 2015. These priorities shall be consistent with the provisions of the Delta Reform Act in promoting effective, prioritized strategic State investments in levee operations, maintenance, and improvements in the Delta for both levees that are a part of the State Plan of Flood Control and nonproject levees. Upon completion, these priorities shall be considered for incorporation into the Delta Plan.

The priorities should identify guiding principles, constraints, recommended cost share allocations, and strategic considerations to guide Delta flood risk reduction investments, supported by, at a minimum, the following actions to be conducted by the California Department of Water Resources, consistent with available funding:

- *An assessment of existing Delta levee conditions. This should include the development of a Delta levee conditions map based on sound data inputs, including, but not limited to:*
  - *Geometric levee assessment*
  - *Flow and updated stage-frequency analysis*
- *An island-by-island economics-based risk analysis. This analysis should consider, but not be limited to, values related to protecting:*
  - *Island residents/life safety*
  - *Property*
  - *Value of Delta islands' economic output, including agriculture*
  - *State water supply*
  - *Critical local, State, federal, and private infrastructure, including aqueducts, state highways, electricity transmission lines, gas/petroleum pipelines, gas fields, railroads, and deep water shipping channels*
  - *Delta water quality*
  - *Existing ecosystem values and ecosystem restoration opportunities*
  - *Recreation*
  - *Systemwide integrity*
- *An ongoing assessment of Delta levee conditions. This should include a process for updating Delta levee assessment information on a routine basis.*

This methodology should provide the basis for the prioritization of State investments in Delta levees. It should include, but not be limited to, the public reporting of the following items:

- *Tiered ranking of Delta islands, based on economics-based risk analysis values*
- *Delta levee conditions status report, including a levee conditions map*
- *Inventory of Delta infrastructure assets*

Improve Residential Flood Protection

To reduce the risk to lives, property, and State interests in the Delta, additional standards are needed to address new residential development. Sea level rise, subsidence, and new residential development combine to potentially put many more lives at risk. The policies in this section are designed to reduce risk while preserving the Delta's unique character and agricultural way of life. These policies should be construed as those required to provide the minimum level of flood protection, and should not be viewed as encouraging development in floodprone Delta areas. Flood insurance, and awareness of local emergency preparedness and response policies is strongly encouraged for all who live in floodprone areas of the Delta.

Consistent with existing law, urban development in the Primary Zone should remain prohibited. Urban development in the Secondary Zone should be confined to existing urban spheres of influence where the 200-year design standard will be fully implemented by 2025. The 2007 flood risk management legislation (SB 5) contained provisions affecting city and county responsibilities relating to local planning requirements, such as general plans, development agreements, zoning ordinances, tentative maps, and other actions (Government Code sections 65865.5, 65962, and 66474.5). Future land use decisions should not permit or encourage construction of significant numbers of new residences in the nonurban Delta. For the legacy communities in the Delta, structures developed in these areas are required to meet the legal standard of a 100-year minimum level of flood protection. However, developing and maintaining adequate flood protection remains difficult.

Problem Statement

Continued residential development without adequate flood protection increases risk to lives, property, and State interests in the Delta. Flood risks are expected to grow in light of anticipated climate change effects related to peak flows and sea level rise.

Policies

The appendices referred to in the policy language below are included in Appendix B of the Delta Plan.

RR P2. Require Flood Protection for Residential Development in Rural Areas

(a) New residential development of five or more parcels shall be protected through floodproofing to a level 12 inches above the 100-year base flood elevation, plus sufficient additional elevation to protect against a 55-inch rise in sea level at the Golden Gate, unless the development is located within:

(1) Areas that city or county general plans, as of May 16, 2013, designate for development in cities or their spheres of influence;

(2) Areas within Contra Costa County's 2006 voter-approved urban limit line, except Bethel Island;

(3) Areas within the Mountain House General Plan Community Boundary in San Joaquin County; or

(4) The unincorporated Delta towns of Clarksburg, Courtland, Hood, Locke, Ryde, and Walnut Grove, as shown in Appendix 7.

(b) For purposes of Water Code section 85057.5(a)(3) and section 5001(j)(1)(E) of this Chapter, this policy covers a proposed action that involves new residential development of five or more parcels that is not located within the areas described in subsection (a).

23 CCR Section 5013
NOTE: Authority cited: Section 85210(i), Water Code.
Reference: Sections 85020, 85300, 85305, and 85306, Water Code.

Protect and Expand Floodways, Floodplains, and Bypasses

Local land use policies guiding development in floodways are not consistent across Delta counties. Floodways have not been established for many of the channels in the Delta by FEMA or by the CVFPB. In light of these inconsistencies, the Delta Plan addresses these issues and highlights the need for the protection of floodplains and floodways consistent with improved flood protection. Over the next 100 years, Delta floodways may expand and deepen because of sea level rise and changing precipitation patterns. Development in existing or potential future designated floodplain or bypass locations in the Delta or upstream of the Delta can permanently eliminate the availability of these areas for future floodplain usage. It is important to identify floodplain areas now for immediate protection and eventual integration into the flood protection system.

Problem Statement

The carrying capacity of the existing flood control system is diminished by encroachments into floodways, critical floodplains, and existing floodplain or bypass locations in the Delta. Local land use policies guiding development in floodways are not consistent across Delta counties. The existing system is already at suboptimal capacity. Expected changes in sea level rise and runoff patterns due to climate change are expected to exacerbate the problem.

Policies

RR P3. Protect Floodways

(a) No encroachment shall be allowed or constructed in a floodway, unless it can be demonstrated by appropriate analysis that the encroachment will not unduly impede the free flow of water in the floodway or jeopardize public safety.

(b) For purposes of Water Code section 85057.5(a)(3) and section 5001(j)(1)(E) of this Chapter, this policy covers a proposed action that would encroach in a floodway that is not either a designated floodway or regulated stream.

23 CCR Section 5014
NOTE: Authority cited: Section 85210(i), Water Code.
Reference: Sections 85020, 85300, 85302, and 85305, Water Code.

RR P4. Floodplain Protection

(a) No encroachment shall be allowed or constructed in any of the following floodplains unless it can be demonstrated by appropriate analysis that the encroachment will not have a significant adverse impact on floodplain values and functions:

(1) The Yolo Bypass within the Delta;

(2) The Cosumnes River-Mokelumne River Confluence, as defined by the North Delta Flood Control and Ecosystem Restoration Project (McCormack-Williamson), or as modified in the future by the California Department of Water Resources or the U.S. Army Corps of Engineers (California Department of Water Resources 2010); and

(3) The Lower San Joaquin River Floodplain Bypass area, located on the Lower San Joaquin River upstream of Stockton immediately southwest of Paradise Cut on lands both upstream and downstream of the Interstate 5 crossing. This area is described in the Lower San Joaquin River Floodplain Bypass Proposal, submitted to the California Department of Water Resources by the partnership of the South Delta Water Agency, the River Islands Development Company, Reclamation District 2062, San Joaquin Resource Conservation District, American Rivers, the American Lands Conservancy, and the Natural Resources Defense Council, March 2011. This area may be modified in the future through the completion of this project.

(b) For purposes of Water Code section 85057.5(a)(3) and section 5001(j)(1)(E) of this Chapter, this policy covers a proposed action that would encroach in any of the floodplain areas described in subsection (a).

(c) This policy is not intended to exempt any activities in any of the areas described in subsection (a) from applicable regulations and requirements of the Central Valley Flood Protection Board.

23 CCR Section 5015
NOTE: Authority cited: Section 85210(i), Water Code.
Reference: Sections 85020, 85300, 85302, and 85305, Water Code.

Recommendations

RR R5. Fund and Implement San Joaquin River Flood Bypass

The Legislature should fund the California Department of Water Resources and the Central Valley Flood Protection Board to evaluate and implement a bypass and floodway on the San Joaquin River near Paradise Cut that would reduce flood stage on the mainstem San Joaquin River adjacent to the urban and urbanizing communities of Stockton, Lathrop, and Manteca in accordance with Water Code section 9613(c).

RR R6. Continue Delta Dredging Studies

The current efforts to maintain navigable waters in the Sacramento River Deep Water Ship Channel and Stockton Deep Water Ship Channel, led by the U.S. Army Corps of Engineers and described in the Delta Dredged Sediment Long-Term Management Strategy (USACE 2007, Appendix K), should be continued in a manner that supports the Delta Plan and the coequal goals. Appropriate dredging throughout other areas in the Delta for maintenance purposes, or that would increase flood conveyance and provide potential material for levee maintenance or subsidence reversal should be implemented in a manner that supports the Delta Plan and coequal goals. Coordinated use of dredged material in levee improvement, subsidence reversal, or wetland restoration is encouraged.

RR R7. Designate Additional Floodways

The Central Valley Flood Protection Board should evaluate whether additional areas both within and upstream of the Delta should be designated as floodways. These efforts should consider the anticipated effects of climate change in its evaluation of these areas.

Integrate Delta Levees and Ecosystem Function

Setback levees can provide additional levee system stability, more complex land-water interface structure, and shaded riverine aquatic habitat that benefit ecosystem function in appropriate settings. They can also provide flood control benefits in those areas of the Delta not subject to strong tidal influences where channel capacity improvements can actually increase flood-carrying capacity. Not all locations are amenable or useful for setback levee placement. Each site should be investigated for its potential to provide ecological benefits consistent with levee integrity.

Problem Statement

Criteria for the development and implementation of setback levees in the Delta have not yet been developed by relevant agencies. These criteria are needed to provide appropriate guidance when considering setback levee siting and design. Currently, agencies have no consistent method for determining the appropriateness of setback levee incorporation as they relate to habitat enhancement and flood control benefit.

Policies

No policies with regulatory effect are included in this section.

Recommendations

RR R8. Develop Setback Levee Criteria

The California Department of Water Resources, in conjunction with the Central Valley Flood Protection Board, the California Department of Fish and Game, and the Delta Conservancy, should develop criteria to define locations for future setback levees in the Delta and Delta watershed.

Limit State Liability

The Delta Reform Act requires that the Delta Plan attempt to reduce risks to people, property, and State interests in the Delta by, among other things, recommending priorities for State investments in levee operation, maintenance, and improvements in the Delta, including project and nonproject levees (Water Code sections 85305, 85306, and 85307). The law expressly states that these provisions do not affect the liability of the State for flood protection in the Delta or its watershed (Water Code section 85032(j)). Consequently, no action taken by a State agency as required or recommended by, or otherwise in furtherance of, this Delta Plan shall affect State flood protection liability in the Delta or its watershed. Therefore, the Legislature should consider requiring an adequate level of flood insurance for residences, businesses, and industries in floodprone areas.

Problem Statement

As the risks of levee failure and corresponding damage increase, California courts have generally exposed public agencies and the State, specifically, to significant financial liability for flood damages. DWR's 2005 white paper recommends one way that the State should reduce its liability is to require houses and businesses to have flood insurance (DWR 2005).

Policies

No policies with regulatory effect are included in this section.

Recommendations

RR R9. Require Flood Insurance

The Legislature should require an adequate level of flood insurance for residences, businesses, and industries in floodprone areas.

RR R10. Limit State Liability

The Legislature should consider statutory and/or constitutional changes that would address the State's potential flood liability, including giving State agencies the same level of immunity with regard to flood liability as federal agencies have under federal law.

Timeline for Implementing Policies and Recommendations

Figure 7-8 lays out a timeline for implementing the policies and recommendations described in the previous section. The timeline emphasizes near-term and intermediate-term actions.

Timeline for Implementing Policies and Recommendations

TIMELINE **CHAPTER 7: Risk Reduction**

	ACTION (REFERENCE #)	LEAD AGENCY(IES)	NEAR TERM 2012–2017	INTERMEDIATE TERM 2017–2025
POLICIES	Prioritization of State investments in Delta levees and risk reduction (RR P1)	Council, DWR, CVFPB	●	
	Require flood protection for residential development in rural areas (RR P2)	Local agencies	●	●
	Protect floodways (RR P3)	CVFPB	●	●
	Floodplain protection (RR P4)	CVFPB	●	●
RECOMMENDATIONS	Implement emergency preparedness and response (RR R1)	Local, State, and federal agencies	●	
	Finance local flood management activities (RR R2)	Legislature, DPC	●	
	Fund actions to protect infrastructure from flooding and other natural disasters (RR R3)	PUC	●	
	Actions for the prioritization of State investments in Delta levees (RR R4)	Council, DWR, CVFPB	●	
	Fund and implement San Joaquin River Flood Bypass (RR R5)	Legislature, DWR, CVFPB	●	
	Continue Delta dredging studies (RR R6)	USACE	●	●
	Designate additional floodways (RR R7)	CVFPB	●	
	Develop setback levee criteria (RR R8)	DWR	●	
	Require flood insurance (RR R9)	Legislature	●	
	Limit State liability (RR R10)	Legislature	●	

DP_346

Agency Key:

Council: Delta Stewardship Council
CVFPB: Central Valley Flood Protection Board
DPC: Delta Protection Commission
DWR: California Department of Water Resources
PUC: California Public Utilities Commission
USACE: U.S. Army Corps of Engineers

Figure 7-8

Issues for Future Evaluation and Coordination

The following list of issues should be considered in future updates of the Delta Plan. These and other issues will need to be considered as additional information and materials become available. The various activities called for in this Delta Plan, as well as issues that arise from other planning efforts, such as the Central Valley Flood Protection Plan, will be considered. Additional areas of interest and concern related to flood risk in the Delta may deserve consideration in the development of future Delta Plan updates, including:

- **Reoperation of Upstream Reservoirs and Peak Flow Attenuation:** Reservoir operations upstream of the Delta can have substantial impacts on flood flows through the Delta; therefore, operation procedures among government agencies should be well coordinated and, where possible, focused more on flexibility to prevent flooding in the Delta. Water Code section 85309 directs DWR to develop a proposal to coordinate flood and water supply operations with appropriate State and federal agencies, and this shall be considered by the Council for future inclusion in the Delta Plan.
- **Utility Corridor Consolidation:** An attempt to consolidate infrastructure into "utility corridors" as facilities are added and upgraded over time should be further investigated to determine whether this can allow for better management of flood risk consequences to these critical assets.
- **State Highways and Sea Level Rise:** The Council will consult with Caltrans regarding the potential effects of climate change and sea level rise on the three state highways that cross the Delta (Water Code section 85307 (c)).

Science and Information Needs

The Delta system and its influencing factors are not static; therefore, research is needed to better understand dynamic issues such as climate change, seismicity, sea level rise, subsidence, and other areas. Continuing investigations into the science, engineering, and economic aspects of the Delta are critical to adaptively managing for expected and unexpected changes, and can provide decision makers and stakeholders with key information for future planning and decision making. Specifically, additional information will be needed in the following areas:

- The interaction between Delta levees and ecosystem function
- Sea level rise: impacts on, and incorporation into, flood risk reduction standards
- Climate change: effects of altered hydrology on levee system integrity
- Effects of seismicity on levee integrity
- Updated flood stage-probability functions
- Potential for subsidence reversal and carbon sequestration from growing native marsh plants
- Understanding the impacts on Delta flood management from upstream flood management infrastructure operations, including reservoir operations
- Technologies for assessing levee integrity

Efforts to address these needs and others that arise during Delta Plan implementation should be undertaken in a systematic fashion so that information developed and lessons learned can be incorporated into future Delta Plan updates.

Performance Measures

Development of informative and meaningful performance measures is a challenging task that will continue after the adoption of the Delta Plan. Performance measures need to be designed to capture important trends and to address whether specific actions are producing expected results. Efforts to develop and track performance measures in complex and large-scale systems like the Delta are commonly multiyear endeavors. The recommended output and outcome performance measures listed below are provided as examples and subject to refinement as time and resources allow. Final administrative performance measures are listed in Appendix E and will be tracked as soon as the Delta Plan is completed.

Output Performance Measures

- New residential development takes into account sea level rise in flood protection planning and development. (RR P2)
- Delta land acreage and the number of reclamation districts with levees below HMP are reduced. (RR P1)
- Freshwater aqueducts passing through the Delta and the primary freshwater channel pathways through the Delta are protected by levees that provide adequate protection against floods and other risks of failure. (RR P1)
- Responsible local, State, and federal agencies with emergency response authority implement the recommendations of the Sacramento-San Joaquin Delta Multi-Hazard Coordination Task Force (Water Code section 12994.5). (RR R1)
- DWR and the CVFPB construct a bypass and floodway on the San Joaquin River near Paradise Cut. (RR R5)

Outcome Performance Measures

- No lives are lost in the Delta as a result of flood emergencies, and economic damages associated with Delta flood emergencies decrease. (RR R1)
- Emergency response and recovery costs are eligible for FEMA reimbursement. (RR P1)
- Water deliveries to East Bay Municipal Utilities District, Contra Costa Water District, the CVP, and the SWP are not interrupted by floods or earthquakes. (RR P1)

References

California Climate Action Team. 2010. *State of California Sea-Level Rise Interim Guidance Document.* Developed by the Sea-Level Rise Task Force of the Coastal and Ocean Working Group, with science support provided by the Ocean Protection Council's Science Advisory Team and the California Ocean Science Trust. October.

Cal EMA (California Emergency Management Agency). 2009. *SEMS Guidelines: Standard Emergency Management System.* November.

Cal EMA and FEMA (California Emergency Management Agency and Federal Emergency Management Agency). 2010. *Memorandum of Understanding Regarding Criteria for Public Assistance Eligibility for Reclamation Districts in the Sacramento/San Joaquin Legal Delta.* February.

California Ocean Protection Council. 2011. *Resolution of the California Ocean Protection Council on Sea Level Rise.* Adopted March 11.

City of Benicia. 2003. General Plan land use designations within Suisun Marsh. Digitized into GIS format by AECOM from City of Benicia Land Use map in 2012.

City of Fairfield. 2008. General Plan land use designations within Suisun Marsh. Received from the City of Fairfield in 2012.

City of Lathrop. 2012. General Plan Land Use map for the City of Lathrop. October. Site accessed March 14, 2013. http://www.ci.lathrop.ca.us/cdd/documents/.

City of Manteca. 2012. General Plan land use designations in GIS format. Received by Eryn Pimentel, AECOM, from Jeffrey Davis, City of Manteca, on September 4.

City of Rio Vista. 2001. General Plan land use designations in electronic non-GIS format. http://www.riovistacity.com/images/Documents/chapter_04.pdf. Accessed 2009.

City of Sacramento. 2008. General Plan land use designations in electronic GIS format. Site accessed 2009. http://www.cityofsacramento.org/gis/data.html.

City of Stockton. 2011a. GIS layers for city spheres of influence. Site accessed April 14, 2011. http://www.stocktongov.com/services/gis/mapdatDat.html.

City of Stockton. 2011b. General Plan land use designations in GIS format and General Plan land use designations within Suisun Marsh (digitized into GIS format by AECOM from Land Use map in 2012). Site accessed April 14, 2011. http://www.stocktongov.com/services/gis/mapdatDat.html.

City of Suisun City. 2011. General Plan land use designations within Suisun Marsh. Digitized into GIS format by AECOM from Land Use map in 2012.

City of Tracy. 2011a. General Plan land use designations provided in GIS format. Delivered via file transfer protocol from Victoria Lombardo, Senior Planner, City of Tracy, to Jessica Law, Urban and Environmental Planner, AECOM, on March 10, 2011.

City of Tracy. 2011b. City of Tracy SOI provided in GIS format. Delivered via file transfer protocol from Victoria Lombardo, Senior Planner, City of Tracy, to Jessica Law, Urban and Environmental Planner, AECOM, on March 10, 2011.

City of West Sacramento. 2010. General Plan land use designations in GIS format. Site accessed December 28, 2010. http://www.cityofwestsacramento.org/services/gis/downloads.cfm.

Contra Costa County. 2008. GIS layer for Urban Limit Line for Contra Costa County. October. Site accessed June 27, 2011. http://ccmap.us/Details/asp?Product=134490.

Contra Costa County. 2010. GIS layer for City Spheres of Influence in Contra Costa County. January. Site accessed January 28, 2011. https://www.ccmap.us/catalog.asp?UserChoice=2&Layercntrl=0000000000000000000000.

Delta Stewardship Council Staff. 2010a. *Flood Risk White Paper*. October 18. http://deltacouncil.ca.gov/docs/delta-plan/2010-10-18/flood-risk-white-paper.

Delta Stewardship Council Staff. 2010b. *Emergency Preparedness and Response White Paper.* November 10. http://deltacouncil.ca.gov/sites/default/files/documents/files/Delta_Emergency_Management_White_Paper_2011_11_08.pdf.

Delta Vision Blue Ribbon Task Force. 2008. *Delta Vision Strategic Plan.* Sacramento, CA. October.

Deverel, S. and D. Leighton. 2010. Historic, Recent, and Future Subsidence, Sacramento–San Joaquin Delta, California, USA. *San Francisco Estuary and Watershed Science.* August.

DPC (Delta Protection Commission). 2012. *Economic Sustainability Plan for the Sacramento-San Joaquin Delta.* January 19.

DPC (Delta Protection Commission). 2010. *Land Use and Resource Management Plan for the Primary Zone of the Delta.* Adopted February 25.

DWR (California Department of Water Resources). 1973. Bulletin 69-72. California High Water 1971-72.

DWR (California Department of Water Resources). 1980. Seismicity hazards in the Sacramento-San Joaquin Delta. Central District. C-105124. October.

DWR (California Department of Water Resources). 2005. *Flood Warnings: Responding to California's Flood Crisis.* White paper. http://www.water.ca.gov/pubs/flood/flood_warnings___responding_to_california's_flood_crisis/011005floodwarnings.pdf.

DWR (California Department of Water Resources). 2008a. *Draft FloodSAFE Strategic Plan.* May 28.

DWR (California Department of Water Resources). 2008b. *Delta Risk Management Strategy (DRMS) 30 Phase 1, Risk Analysis Report, Final.* Prepared by URS Corporation/Jack R. Benjamin & 31 Associates, Inc. Prepared for DWR, USACE, and California Department of Fish and Game. December. http://www.water.ca.gov/floodmgmt/dsmo/sab/drmsp/phase1_information.cfm.

DWR (California Department of Water Resources). 2008c. *Managing an Uncertain Future: Climate Change Adaptation 13 Strategies for California's Water.* Sacramento, CA.

DWR (California Department of Water Resources). 2009. *Delta Risk Management Strategy Final Phase 1 Report.* March.

DWR (California Department of Water Resources). 2010. *North Delta Flood Control and Ecosystem Restoration Project Final Environmental Impact Report.* Sacramento, CA. October.

DWR (California Department of Water Resources). 2011a. *Delta Risk Management Strategy Phase 2 Report.* June.

DWR (California Department of Water Resources). 2011b. *Draft Urban Levee Design Criteria.* November 15.

DWR (California Department of Water Resources). 2011c. *Central Valley Flood Protection Plan* (Public Draft). December.

DWR (California Department of Water Resources). 2011d. Floodplain inundation and floodways in the vicinity of the Sacramento-San Joaquin delta.

DWR (California Department of Water Resources). 2011e. Locations and attributes of levees in California as maintained by the DWR California Levee Database.

DWR (California Department of Water Resources). 2012. *Report to Delta Stewardship Council on the Department of Water Resources' Delta Levees Program.* March 15.

DWR and DFG (California Department of Water Resources and California Department of Fish and Game). 2008. *A Report Pursuant to Requirements of Assembly Bill 1200, Laird, Risks and Options to Reduce Risks to Fishery and Water Supply Uses of the Sacramento/San Joaquin Delta.* January.

FEMA (Federal Emergency Management Agency). 1994. Mitigation of Flood and Erosion Damage to Residential Buildings in Coastal Areas. FEMA 257. October.

FEMA (Federal Emergency Management Agency). 2001. *Ensuring that Structures Built on Fill In or Near Special Flood Hazard Areas Are Reasonably Safe from Flooding in Accordance with the National Flood Insurance Program.* FIA-TB-10. May.

FEMA (Federal Emergency Management Agency). 2006. *National Flood Insurance Program (NFIP) Floodplain Management Requirements: A Study Guide and Desk Reference for Local Officials.* Unit 3: NFIP Flood Studies and Maps. Figure 3-6. Site accessed July 7, 2011. http://www.fema.gov/library/viewRecord.do?id=2165.

Healey, M., and J. Mount. 2007. *Delta Levees and Ecosystem Function.* CALFED Bay-Delta Program.

Jones & Stokes. 2007. *Draft Environmental Impact Report North Delta Flood Control and Ecosystem Restoration Project.* Volume 2-Figures. November.

Miller, Robin. 2008. *Subsidence Reversal in a Re-established Wetland in the Sacramento-San Joaquin Delta, California, USA.* U.S. Geological Survey.

Mount, J., and R. Twiss. 2005. *Subsidence, Sea Level Rise, Seismicity in the Sacramento–San Joaquin Delta.*

Mountain House Community Services District. 2008. Mountain House Zoning map. September 18, 2008. Site accessed July 27, 2011. http://www.ci.mountainhouse.ca.us/master-plan.asp.

MWD (Metropolitan Water District of Southern California). 2010. 6.5 Magnitude Earthquake Causing 20-Island Failure. Modeling and graphics developed by Resource Management Associates and 34 North for the Metropolitan Water District of Southern California.

National Committee on Levee Safety. 2009. *Draft: Recommendations for a National Levee Safety Program.* January 15. http://www.nfrmp.us/ncls/docs/NCLS-Recommendation-Report_012009_DRAFT.pdf.

SACOG (Sacramento Area Council of Governments). 2009. GIS layer for Spheres of Influence in SACOG region. December. Site accessed January 28, 2011. http://sacog.org/mapping/clearinghouse/Mapping Center.

Sacramento County. 2011. General Plan land use designations in GIS format. Site accessed 2012. http://www.sacgis.org/GISDataPub/Data/.

Sacramento County. 2012. Letter from Sacramento County to the Delta Stewardship Council, Re: Revised Maps of the Unincorporated Delta Communities. November 20.

Sacramento County. 2013. Sacramento County Online Map, Sacramento County, California. http://generalmap.gis.saccounty.net/JSViewer/county_portal.aspx Accessed March 10, 2013.

Sacramento River Delta Historical Society. 1996. Andrus Island. *Sacramento River Delta Historical Society Newsletter.* Vol. 16, No. 2. December.

San Joaquin County. 2008a. City of Lathrop sphere of influence map. March 4. Site accessed February 3, 2011. http://www.sjgov.org/lafco/SOI%20Maps/Lathrop_Sphere_new%202008.pdf.

San Joaquin County. 2008b. City of Manteca sphere of influence map. October 29. Site accessed February 3, 2011. http://www.co.san-joaquin.ca.us/lafco/Manteca%20MSR/Manteca_Sphere.pdf.

Shields, F.D., and D.H. Gray. 1992. Effects of woody vegetation on sandy levee integrity. Journal of the American Water Resources Association 28:917–931.

Solano County. 2008a. GIS layer for City Spheres of Influence in Solano County. May. Site accessed August 10, 2011. http://regis.solanocounty.com/data.html.

Solano County. 2008b. General Plan land use designations provided in GIS format. Obtained 2009.

South Delta Levee Protection and Channel Maintenance Authority. 2011. *Lower San Joaquin Flood Bypass Proposal.* March.

USACE (U.S. Army Corps of Engineers). 1996. EM 1110-2-1619. *Risk-based Analysis for Flood Damage Reduction Studies.* August 1.

USACE (U.S. Army Corps of Engineers). 2002. *Sacramento and San Joaquin River Basins California Comprehensive Study, Interim Report.* Sacramento District.

USACE (U.S. Army Corps of Engineers). 2006. ER 1105-2-101. *Risk Analysis for Flood Damage Reduction Studies.* January 3.

USACE (U.S. Army Corps of Engineers). 2007. *Delta Dredged Sediment Long-Term Management Strategy (Pinole Shoal Management Area).* Study Work Plan. Management Committee Review Draft. San Francisco District. May 9.

USGS (U.S. Geological Survey). 2011. Atmospheric rivers, floods and the water resources of California. Water 3(2):445-478. http://www.mdpi.com/2073-4441/3/2/445.

Yolo County. 2010a. General Plan land use designations in GIS format. Site accessed 2010. http://www.yolocounty.org/Index.aspx?page=823.

Yolo County. 2010b. Yolo County General Plan 2030 layer provided in GIS format. Delivered via file transfer protocol from Marcus Neuvert, GIS Specialist, Yolo County DITT, to Dillon Cowan, Staff Engineer, CH2M HILL, Inc., on July 1.

Photo Credits

Chapter divider: All photos courtesy of California Department of Water Resources

CHAPTER 8

Funding Principles to Support the Coequal Goals

ABOUT THIS CHAPTER

This chapter provides background information on federal, State of California (State), and local spending for water supply, water quality, flood management, and Delta ecosystem purposes. It proposes the development of a comprehensive finance plan to implement the Delta Plan. It also sets forth guiding principles for the development of a finance plan and proposes near-term funding for support of the Delta Protection Commission, Sacramento-San Joaquin Delta Conservancy, and the Delta Stewardship Council (Council).

A 5-year budget is included in Appendix M. And, as described in Chapter 2, successful implementation of the Delta Plan will depend upon many independent agency authorities and actions under the coordination and leadership of the Council.

CHAPTER 8

Funding Principles to Support the Coequal Goals

In establishing the coequal goals, the Delta Reform Act affirmatively reset spending priorities for the Delta ecosystem and water management. Inherent in the coequal goals is a new governance structure (primarily the Council), which the Legislature intended to have the "authority, responsibility, accountability, scientific support, and adequate *and secure funding to achieve these objectives*." The Council was directed to develop a long-term, legally enforceable management plan for the Delta, and in implementing the Delta Plan, to "direct actions across State agencies," in part through the establishment of an Interagency Implementation Committee. Additionally, as addressed in the preceding Delta Plan chapters, the Delta Reform Act set forth a number of policy objectives and other requirements for how the Delta Plan must be developed and what it must contain, ranging from broad guidance on types of projects the Plan should promote, to specific performance measures for evaluating progress on ecosystem restoration. Accordingly, the Council set forth several priority recommendations and regulatory policies, which together make up this Delta Plan.

The Delta Reform Act does not require the development of a financing plan for the implementation of the Delta Plan; however, given the current economic climate, recent uneven funding for water and ecosystem investment, and the critical nature of what is at stake should the coequal goals fail to be achieved, the Council affirmed the need for a financing plan and is committed to its development.

As the Public Policy Institute of California succinctly stated in its 2011 report on water management in California, "Although money alone is not sufficient for successful water management, it is necessary" (Public Policy Institute of California 2011). In introducing any discussion on financing, particularly in the public sector, it is necessary to acknowledge the political and economic context. America is currently suffering a severe recession, and California's economy has fared even worse. The State has experienced a multiyear budget crisis in which annual spending exceeds available revenue. As a result, financing infrastructure and new programs has become immensely challenging for State and local governments.

Today's economic conditions may limit the ability to adequately finance a full range of water and ecosystem improvements necessary to achieve the coequal goals in the near term. However, the planning timeframe for the Delta Plan runs to the year 2100, and decisions on long-term, sustainable financing for water, ecosystem, and flood protection cannot be delayed much longer without grave and expensive consequences. A long planning horizon allows near-term foundational steps to be taken now toward improving the situation and for implementing agencies to stage actions, policies, and projects over time consistent with an adaptive management structure based on science. Additionally, some activities to implement the Delta Plan are currently funded or can be undertaken with no additional cost, and many of the actions called for in the Delta Plan are certain to result in significant long-term cost savings.

Because of the complex nature of the policy issues and of certain funding and finance methods, a comprehensive and supportable Delta Plan finance plan will take time to develop. Thorough research is needed to identify entities that may be assessed user or stressor fees, determine appropriate levels for these fees, establish tiered fee structures, calculate the public benefits, and work through the legal implications of any financing strategy, including the practical effects of Propositions 218 and 26 on State and local financing mechanisms.

Background

Since the CALFED Bay-Delta Program was instituted in 1995 to restore ecological health and improve water management in the Delta, significant expenditures have been made in the Delta. An estimated $400 million has been spent annually, on average, by federal, State, and local water users.

Traditionally, the State has financed water infrastructure with general obligation bonds. These bonds were approved by the voters, and repayment is guaranteed by the State's general taxing power. With respect to State Water Project (SWP) debt, however, even though repayment was secured by taxes, general obligation bonds were paid back primarily by the water contractors. Since 2000, California voters have authorized $19.4 billion in water-related general obligation bonds spread over six separate bonds (LAO 2008). Several of these bonds authorize expenditures for a multitude of purposes, including assorted water projects, parkland acquisition, habitat restoration, and local assistance grants. One benefit of financing water projects with general obligation bonds is that any expenditure made for a public purpose is repaid by taxpayers, the primary beneficiaries. Currently, remaining fund balances for active bond accounts total approximately $2.2 billion out of the authorized total of $19.4 billion, only a portion of which is for Delta-related spending.

Table 8-1 summarizes the current balances for general obligation bonds by individual bond act related to water, ecosystem restoration, and flood protection. It is important to note that these remaining balances are not fungible; that is, statute generally dictates the specific types of projects or programs on which funds can be spent.

Currently scheduled for the November 2014 ballot, the Safe, Clean, and Reliable Drinking Water Supply Act of 2012 would authorize, upon voter approval, the issue and sale of $11.14 billion in general obligation bonds for financing drought relief projects, water supply reliability projects, Delta sustainability projects, water system improvements, watershed and conservation protection programs, groundwater protection and water quality projects, and water recycling projects. Key Delta projects include $2.25 billion for protection of water supplies from catastrophic levee failure, drinking water quality improvements, levee and flood control facilities improvements, lost property tax replacement, ecosystem restoration, and contaminants reduction.

General Obligation Bonds – California (as of January 2013)

TABLE 8-1

Bond Act (Year)	Authorized ($ Thousands)	Committed ($ Thousands)	Balance ($ Thousands)
Proposition 12 (2000)	2,024,486	6,189	18,456
Proposition 13 (2000)	2,103,000	1,823,874	279,126
Proposition 40 (2002)	2,471,600	16,556	26,536
Proposition 50 (2002)	3,382,630	0	0
Proposition 1E (2006)	4,090,000	4,024,354	65,646
Proposition 84 (2006)	5,388,000	5,080,840	307,160
Total	**$19,378,411**	**$17,221,349**	**$2,157,062**

Although general obligation bonds have been an important part of how California has funded water and ecosystem projects in the past, because of the uncertainty regarding voter approval of future bonds, a more sustainable and long-term financing approach for water, ecosystem, flood protection, and related projects is needed. As new revenue sources are developed, the use of revenue bonds may become more prevalent. For example, the SWP routinely sells and redeems revenue bonds to pay the costs of planning and construction, bond interest, and project operating expenses, as do many local agencies.

Federal-level expenditures in California in recent years have declined as grant programs for wastewater treatment in the late 1970s and 1980s expired, and flood control spending was reduced. It is likely that large federal budget deficits for the foreseeable future will preclude any increases in federal funds for California water projects.

Although State-level expenditures for water-related programs and projects in recent years have been almost entirely funded with general obligation bonds, this contrasts somewhat with the financing methods available to local agencies. Although many of these agencies have at times issued general obligation bonds and revenue bonds, it is more common for them to establish stable income streams by charging dedicated fees to ratepayers to pay the costs of infrastructure projects including water treatment and wastewater systems.

The ability of local agencies to fund flood control and stormwater projects, however, is specifically governed by the provisions of Proposition 218, approved by California voters in 1996. Under Proposition 218, direct voter approval by a majority of property owners or a two-thirds vote of the general public is required to raise funds for these purposes. Results of local Proposition 218 elections in recent years have been mixed, with some agencies gaining voter approval and others falling short of funding needed for local projects. For example, Sacramento voters successfully approved new assessments for flood control projects in 2007, but 1 year later, voters in Orinda (East Bay Area) and Burlingame (Bay Area) failed to approve new assessments for the same purpose (Public Policy Institute of California 2011).

A companion measure, Proposition 26, approved by voters in 2010, effectively raised voting requirements for most State and local regulatory fees from a simple majority to a two-thirds majority. Regulatory fees with a broad public purpose are considered taxes and are subject to a two-thirds vote of the Legislature. Local agencies are also required to seek a two-thirds vote of the general public.

The best available information shows that total annual federal, State, and local spending on water and wastewater treatment in California is approximately $24 billion (see Table 8-2). Operations, maintenance, and capital expenditures for water infrastructure consume significant economic resources in California. This total likely includes some overlap, but the expenditures are significant. Other sources cite higher expenditures for some of these categories. During development of the finance plan, this table will be updated to reflect the most recent data.

Bay Delta Conservation Plan

Described in various sections of this Delta Plan, the Bay Delta Conservation Plan (BDCP) is a massive water and ecosystem public works planning process under way in the Delta. The Council supports the completion of the BDCP according to the provisions set forth in the Delta Reform Act. The scope or type of any water facility improvements, related Delta ecosystem mitigation, and other habitat improvements to be included is very preliminary at this time. The BDCP's ongoing planning costs are currently funded by State and federal water contractors. Currently available information from the BDCP indicates that, once it is completed, the first 5 years of implementation will require between $5.7 and $5.9 billion total for capital outlay, of which approximately $5.2 billion is for water conveyance. Additionally, the BDCP estimates that $3.6 billion total plus $46 million annually will be required for Delta ecosystem

Annual Budgets/Expenditures in California for Selected Agencies

TABLE 8-2

	Budget/Expenditures		
Agency	Operating ($ Millions)	Capital ($ Millions)	Source
Local cities, counties, and special districts water	10,100	2,000	California State Controller 2011a, 2011b, 2011c
Local cities, counties, and special districts wastewater	5,400	1,100	California State Controller 2011a, 2011b, 2011c
Local cities, counties, and special districts flood control	1,000	300	California State Controller 2011a, 2011b, 2011c
California Department of Water Resources	2,267	232	California Department of Finance 2012
State Water Resources Control Board	714		California Department of Finance 2012
California Department of Fish and Wildlife	381		California Department of Finance 2012
Bureau of Reclamation	300		Bureau of Reclamation 2008
U.S. Army Corps of Engineers	100	100	U.S. Army Corps of Engineers 2008
Total	**$20,262**	**$3,732**	

restoration (BDCP Steering Committee 2010). The BDCP will include a funding plan that will address estimated implementation costs and sources of funding that will be relied upon to cover these costs. The sidebar, Bay Delta Conservation Plan Costs and Existing Funding Sources, provides additional background information about the BDCP.

Overview of Current State and Federal Delta-related Expenditures

The CALFED Bay-Delta Program was incorporated into the Council in 2010. However, some program elements endure because bond funds are dedicated by law for CALFED purposes. Additionally, the CALFED program is still referenced in federal statutes. For these reasons, an annual cross-cut budget showing State and federal expenditures for active CALFED programs and projects is developed each January.

Because the cross-cut budget includes State and federal expenditure details on all the CALFED programs, those data can be summarized to show expenditures for program elements displayed in the budget. The results are shown in Table 8-3.

Annual State and Federal Expenditures in California by Program Element (2012–2013)

TABLE 8-3

Program Element	California	Federal	Total
Governance	$21,145,596	$20,490,000	$41,635,596
Water Supply Reliability	$161,523,833	$18,774,000	$180,297,833
Ecosystem Restoration	$64,119,524	$92,275,000	$156,394,524
Water Quality	$6,368,631	$5,000,000	$11,368,631
Risk Reduction/Levee Integrity	$8,949,231	$45,560,000	$54,509,231
Total	**$262,106,815**	**$182,099,000**	**$444,205,815**

BAY DELTA CONSERVATION PLAN COSTS AND EXISTING FUNDING SOURCES

Potential future funding sources for the BDCP will likely compete with funding required for implementation of some elements of the Delta Plan, and for the plans and projects of State, federal, and local agencies. The Council does not consider any funding source to be solely available for the BDCP, or for any other program or plan. They are solely considered to be options at this stage.

Based on current information from the BDCP, the approximate costs of a facility and related ecosystem improvements needed for State and federal approval are approximately $15.8 to $16.7 billion in capital costs and an additional $4.9 to $5.6 billion in operating costs over the 50-year permit period. These costs are divided among the BDCP's four primary functions—water conveyance, habitat restoration, management of other stressors, and program oversight—as shown in the table below. The Council notes that preliminary cost estimates are just that: preliminary. Going forward, refined estimates will be required to complete this planning process.

Options for BDCP Funding

The BDCP is premised on the pledge of participating State and federal water contractors to pay the full cost of any new Delta export facility and the associated Delta ecosystem mitigation required to meet the requirements imposed on the BDCP by federal and State laws. Habitat and ecosystem restoration activities, beyond mitigation requirements, are considered to provide a general benefit to the State and should be funded accordingly.

Prior to completion of the BDCP and a full understanding of the Delta ecosystem improvements related to the BDCP, it is impossible to project the detailed funding options that might be necessary. However, it is highly likely that user fees, revenue bonds, and sources other than the State General Fund will be the primary sources of funding.

Summary of BDCP Costs and Existing Funding Sources ($ millions)

	Bay Delta Conservation Plan[a]		
Program Function	**Capital Costs**	**Operating Costs**	**Total**
Water Conveyance[b]	$12,691	$2,936	$15,627
Habitat Restoration[c]	$3,108–$4,009	$346–$437	$3,454–$4,446
Other Stressors[c]	$12–$15	$1,213–$1,679	$1,225–$1,694
Program Oversight[c]		$404–$548	$404–$548
Total	$15,811–$16,715	$4,899–$5,600	$20,710–$22,315

[a] Over 50-year permit period [b] Midpoint cost estimate [c] Range of low-high estimate given

Source: BDCP Steering Committee, 2010

DP-171

A Delta Finance Plan

The Council proposes to initiate development of a finance plan following adoption of the Delta Plan. This process will require the active participation of the Interagency Implementation Committee described in Chapter 2. Financing and funding mechanisms to be considered in developing the finance plan are included in Appendix N.

Guiding Principles

A finance plan to fund the Delta Plan should follow these principles:

- The finance plan should first consider currently available funds that can legally support expenditures for Delta-related projects. Spending priorities should be established that address near-term funding requirements as contained in this Delta Plan.
- Implementation of the Delta Plan will undoubtedly require an array of funding sources, including new funding sources and new statutory authority. Broad-based financing and diversity in funding sources will enhance revenue stability. Likewise, State and federal funds for activities that implement the Delta Plan must be reserved for public benefits not otherwise required for project mitigation or required by law for other purposes. Appendix N describes potential funding sources.
- The Delta Plan recommends many projects that have multiple benefits; this increases opportunities to blend fund sources and builds on the tradition of past investments in multipurpose water projects with diversified fund sources.
- A clear and analytically based methodology for assessing public benefits should be evaluated and implemented.
- Targeted finance plans should be developed for major Delta Plan plans and projects (ecosystem restoration, flood risk reduction, regional water supply investments, science, administration, and water conveyance). Beneficiaries and stressors should be identified in each of these areas, and user fees should be developed to match these stressors and beneficiaries with planned investments in each of these areas.
- Economic and financial analyses should be done as early as possible during the planning of large capital projects. This will assist agencies in the design of cost-effective projects and will help ensure that the projects are actually completed and implemented. Financial analyses should account for all of the costs of a project, both direct and indirect, including acquisition, planning, capital and interest, mitigation, science and monitoring, and operations and maintenance.

User Fees

- User fees, including beneficiary fees and stressor fees, are essential and should be established to support the coequal goals and the implementation of the Delta Plan.
- The "beneficiaries pay" principle is a common financing approach for water projects. The challenge is to determine the beneficiaries and design a cost-allocation method scaled to the benefit.
- A companion principle to "beneficiaries pay" is "stressors pay." Human activity that causes negative operational or environmental impacts should be assessed a fee, or otherwise charged, to repair the damage. An example of the stressors pay approach might be a surcharge on pesticides that are found to negatively impact the Delta ecosystem. Capital construction projects, whether for water reliability purposes or Delta ecosystem improvements, should be undertaken simultaneously with the development of beneficiary and user fees. Delay in establishing beneficiaries/stressors fee structures will inevitably delay any needed capital improvement projects. The development of information related to financing (such as the identification of beneficiaries and stressors, and detailed financing scenarios) should be undertaken simultaneously with the development of major capital decisions so that it can inform planning efforts.

- The finance plan should include mechanisms to ensure that user fees are legally dedicated to their intended purpose. Given State and federal budget constraints, statutory protections must be enacted to assure users that their assessments will not be diverted to other purposes.
- The finance plan should include opportunities to generate revenue when planning projects, where possible, to ensure long-term financing stability.
- To the extent possible, user fees should be based on the amount of water used or, for stressors, the volume of contaminants discharged. Tiered fee structures also should be explored where applicable.
- Long-term, stable funding approaches, such as the Delta Flood Risk Management Assessment District recommended in Chapter 7 or other beneficiary user fees, should be established to support the Delta Levees Maintenance Subventions Program, Delta Levees Special Flood Control Projects Program, and implementation of the Central Valley Flood Protection Plan.

Near-term and Annual Funding Requirements

The following items describe activities that must be addressed and funded as soon as possible. They describe the urgent need to immediately address the steps needed to achieve the coequal goals, begin implementation of the Delta Plan, and establish annual funding for key Delta agencies:

- **Urgent expenditures for water supply reliability and ecosystem protection.** Immediate steps should be taken to protect the existing Delta water export system from flood risks and carry out ecosystem improvements being implemented pursuant to existing mitigation commitments of the SWP and the Central Valley Project. Those immediate needs are discussed in the various chapters of the Delta Plan.
- **Create a regional Delta Flood Risk Management Assessment District.** The Legislature should create a regional district with the authority to assess fees on Delta levee beneficiaries, including landowners, infrastructure owners, and other entities, to fund flood control protection, including levee maintenance and improvement, and emergency response, as recommended in Chapter 7.
- **Fund a strong Delta Science Program.** Funding is needed for continued operation of the Independent Science Board, development of the proposed Delta Science Plan, the State's share of the Interagency Ecological Program, and other activities that support a strong science foundation for Delta Plan implementation. Funding for the Interagency Ecological Program should continue from participating agencies.
- **Fund urban and agricultural water management plans.**
- **Continue the existing operational duties imposed by the Delta Reform Act.** The Act created the Council (which includes the Delta Science Program and Independent Science Board) and the Sacramento-San Joaquin Delta Conservancy, and modified the duties of the Delta Protection Commission. Future estimated annual operating costs for these agencies are provided in Appendix M.
- **Fees for services.** The Legislature should grant authority to the Council to assess fees to cover the costs of providing specified services related to covered actions, specifically early consultations and reviewing appeals of consistency certifications.

POLICIES AND RECOMMENDATIONS

Administrative performance measures for the following recommendations can be found in Appendix E.

FP R1 Conduct Current Spending Inventory

An inventory of current State and federal spending on programs and projects that do or may achieve the coequal goals will be conducted. Data sources to be used include the CALFED cross-cut budget, State bond balance reports, and the annual State budget, among others. Consideration will be given to selecting an independent agency (which could include a nongovernmental organization) to conduct the inventory.

FP R2 Develop Delta Plan Cost Assessment

Costs will be assigned to the projects and programs proposed in the Delta Plan (Chapters 2 through 7), and sources of funding will be identified.

FP R3 Identify Funding Gaps

Current State and federal funding gaps will be identified that are determined to hinder progress toward meeting the coequal goals.

Timeline for Implementing Recommendations

Figure 8-1 lays out a timeline for implementing the recommendations described in the previous section.

Timeline for Implementing Recommendations

TIMELINE CHAPTER 8: Funding Principles to Support the Coequal Goals

	ACTION (REFERENCE #)	LEAD AGENCY	NEAR TERM 2012–2017	INTERMEDIATE TERM 2017–2025
RECOMMENDATIONS	Conduct current spending inventory (FP R1)	Council	●	
	Develop Delta Plan cost assessment (FP R2)	Council	●	
	Identify funding gaps (FP R3)	Council	●	

Agency Key:
Council: Delta Stewardship Council

DP_357

Figure 8-1

References

BDCP Steering Committee (Bay Delta Conservation Plan Steering Committee). 2010. *Progress Report on the Bay Delta Conservation Plan.* November 18.

Bureau of Reclamation. 2008. Fiscal Year 2009 Budget for the U.S. Bureau of Reclamation. Accessed May 18, 2011. http://www.usbr.gov/budget/2009/CONTENTS.pdf.

California Department of Finance. 2012. 2012-13 California Budget. http://ebudget.ca.gov/.

California State Controller. 2011a. *Cities Annual Report*, Fiscal Year 2008-09. Accessed May 18, 2011. http://www.sco.ca.gov/Files-ARD-Local/LocRep/cities_reports_0809cities.pdf.

California State Controller. 2011b. *Counties Annual Report*, Fiscal Year 2008-09. Accessed May 18, 2011. http://www.sco.ca.gov/Files-ARD-Local/LocRep/counties_reports_0809counties.pdf.

California State Controller. 2011c. *Special Districts Annual Report*, Fiscal Year 2008-09. Accessed May 18, 2011. http://www.sco.ca.gov/Files-ARD-Local/LocRep/districts_reports_0809_specialdistricts.pdf.

LAO (California Legislative Analyst's Office). 2008. *California's Water: An LAO Primer*.

Public Policy Institute of California. 2011. *Managing California's Water: From Conflict to Resolution*.

U.S. Army Corps of Engineers. 2008. Fiscal Year 2009 Civil Works Budget for the U.S. Army Corps of Engineers. Accessed May 18, 2011. http://www.usace.army.mil/CECW/PID/Documents/budget/budget2009.pdf.

Photo Credits

Chapter divider: (clockwise from top left): California Department of Water Resources, California Department of Water Resources, and ZoArt Photography

This page intentionally left blank.

Glossary

This page intentionally left blank.

Glossary

The first section of this glossary provides definitions that appear in 23 California Code of Regulations section 5001. The second section provides definitions and explanations of key terms, acronyms, and abbreviations used in the Delta Plan.

Definitions in 23 California Code of Regulations Section 5001

As used in this division, the terms listed below shall have the meanings noted:

(a) "Adaptive management" means a framework and flexible decision-making process for ongoing knowledge acquisition, monitoring, and evaluation leading to continuous improvement in management planning and implementation of a project to achieve specified objectives.

(b) "Agricultural water management plan" means a plan prepared, adopted, and updated by an agricultural water supplier pursuant to the Agricultural Water Management Planning Act, Water Code section 10800 et seq.

(c) "Agricultural water supplier" under the Water Code refers to both agricultural retail water suppliers and agricultural wholesale water suppliers, but not the California Department of Water Resources or the United States Bureau of Reclamation, and includes both of the following:

(1) A water supplier, either publicly or privately owned, providing water to 10,000 or more irrigated acres, excluding recycled water; and

(2) A water supplier or contractor for water, regardless of the basis of the water right, that distributes or sells water for ultimate resale to customers.

(d) "Base Flood" means the flood that has a 1-percent probability of being equaled or exceeded in any given year (also referred to as the 100-year flood).

(e) "Base Flood Elevation" (BFE) means the water surface elevation associated with the base flood.

(f) "Best available science" means the best scientific information and data for informing management and policy decisions. Best available science shall be consistent with the guidelines and criteria found in Appendix 1A.

(g) "Central Valley Flood Protection Board" or "Board" means the Central Valley Flood Protection Board (formerly The Reclamation Board) of the Resources Agency of the State of California as provided in Water Code section 8521.

(h) "Coequal goals" means the two goals of providing a more reliable water supply for California and protecting, restoring, and enhancing the Delta ecosystem. The coequal goals shall be achieved in a manner that protects and enhances the unique cultural, recreational, natural resource, and agricultural values of the Delta as an evolving place. In addition, "achievement" for the purpose of determining whether a plan, program, or project meets the definition of a ''covered action'' under section 5001(j) is further defined as follows:

(1) "Achieving the coequal goal of providing a more reliable water supply for California" means all of the following:

(A) Better matching the state's demands for reasonable and beneficial uses of water to the available water supply. This will be done by promoting, improving, investing in, and implementing projects and programs that improve the resiliency of the state's water systems, increase water efficiency and conservation, increase water recycling and use of advanced water technologies, improve groundwater management, expand storage, and improve Delta conveyance and operations. The evaluation of progress toward improving reliability will take into account the inherent variability in water demands and supplies across California;

(B) Regions that use water from the Delta watershed will reduce their reliance on this water for reasonable and beneficial uses, and improve regional self-reliance, consistent with existing water rights and the State's area-of-origin statutes and Reasonable Use and Public Trust Doctrines. This will be done by improving, investing in, and implementing local and regional projects and programs that increase water conservation and efficiency, increase water recycling and use of advanced water technologies, expand storage, improve groundwater management, and enhance regional coordination of local and regional water supply development efforts; and

(C) Water exported from the Delta will more closely match water supplies available to be exported, based on water year type and consistent with the coequal goal of protecting, restoring, and enhancing the Delta ecosystem. This will be done by improving conveyance in the Delta and expanding groundwater and surface storage both north and south of the Delta to optimize diversions in wet years when more water is available and conflicts with the ecosystem are less likely, and limit diversions in dry years when conflicts with the ecosystem are more likely. Delta water that is stored in wet years will be available for water users during dry years, when the limited amount of available water must remain in the Delta, making water deliveries more predictable and reliable. In addition, these improvements will decrease the vulnerability of Delta water supplies to disruption by natural disasters, such as, earthquakes, floods, and levee failures.

(2) "Achieving the coequal goal of protecting, restoring, and enhancing the Delta ecosystem" means successfully establishing a resilient, functioning estuary and surrounding terrestrial landscape capable of supporting viable populations of native resident and migratory species with diverse and biologically appropriate habitats, functional corridors, and ecosystem processes.

(3) "Achieving the coequal goals in a manner that protects and enhances the unique cultural, recreational, natural resource, and agricultural values of the Delta as an evolving place" means accepting that change, including change associated with achieving the coequal goals, will not cease, but that the fundamental characteristics and values that contribute to the Delta's special qualities and that distinguish it from other places can be preserved and enhanced while accommodating these changes. In this regard, the following are core strategies for protecting and enhancing the unique values that distinguish the Delta and make it a special region:

(A) Designate the Delta as a special place worthy of national and state attention;

(B) Plan to protect the Delta's lands and communities;

(C) Maintain Delta agriculture as a primary land use, a food source, a key economic sector, and a way of life;

(D) Encourage recreation and tourism that allow visitors to enjoy and appreciate the Delta and that contribute to its economy;

(E) Sustain a vital Delta economy that includes a mix of agriculture, tourism, recreation, related industries and business, and vital components of state and regional infrastructure; and

(F) Reduce flood and other risks to people, property, and other interests in the Delta.

(i) "Commercial recreational visitor-serving uses" means a land use designation that describes visitor-serving uses, accommodations, restaurants, and shops, that respect the rural character and natural environmental setting. These uses also include campgrounds and commercial recreational facilities.

(j)(1) "Covered action" means a plan, program, or project that meets all of the following criteria (which are collectively referred to as covered action screening criteria):

(A) Is a "project," as defined pursuant to section 21065 of the Public Resources Code;

(B) Will occur, in whole or in part, within the boundaries of the Delta or Suisun Marsh;

(C) Will be carried out, approved, or funded by the State or a local public agency;

(D) Will have a significant impact on achievement of one or both of the coequal goals or the implementation of government-sponsored flood control programs to reduce risks to people, property, and State interests in the Delta; and

(E) Is covered by one or more provisions of the Delta Plan, which for these purposes, means one or more of the regulatory policies contained in Article 3.

(2) ''Covered action'' does not include any plan, program, or project that is exempted pursuant to Water Code section 85057.5(b).

(3) A State or local public agency that proposes to carry out, approve, or fund a plan, program, or project that may be subject to this Chapter must determine whether that proposed plan, program, or project is a covered action. That determination, which is subject to judicial review, must be reasonable, made in good faith, and consistent with the Delta Reform Act and this Chapter.

(4) Nothing in the application of the definition of a "covered action" shall be interpreted to authorize the abrogation of any vested right whether created by statute or by common law.

(k) "Delta" means the Sacramento-San Joaquin Delta as defined in section 12220 of the Water Code and the Suisun Marsh, as defined in section 29101 of the Public Resources Code.

(l) "Delta Plan" means the comprehensive, long-term management plan for the Delta to further the achievement of the coequal goals, as adopted by the Delta Stewardship Council in accordance with the Sacramento-San Joaquin Delta Reform Act of 2009.

(m) "Designated Floodway" means those floodways, as defined in California Code of Regulations, Title 23, section 4(i), under the jurisdiction of the Central Valley Flood Protection Board.

(n) "Encroachment" means any obstruction or physical intrusion by construction of works or devices, planting or removal of vegetation, or by any means for any purpose, into or otherwise affecting a floodway or floodplain.

(o) "Enhancement" or "enhancing," for purposes of section 5001(h)(2), means improving existing desirable habitat and natural processes. Enhancement may include, by way of example, flooding the Yolo Bypass more often to support native species or to expand or better connect existing habitat areas. Enhancement includes many fish and wildlife management practices, such as managing wetlands for waterfowl production or shorebird habitat, installing fish screens to reduce entrainment of fish at water diversions, or removing barriers that block migration of fish to upstream spawning habitats.

(p) "Feasible" means capable of being accomplished in a successful manner within a reasonable period of time, taking into account economic, environmental, legal, social, and technological factors.

(q) "Floodplain" means any land area susceptible to being inundated by flood waters from any source.

(r) "Floodplain values and functions" has the same meaning as set forth in 33 Code of Federal Regulations section 320.4(l)(1).

(s) "Floodproofing" means any combination of structural and nonstructural additions, changes, or adjustments appropriate for residential structures, which reduce or eliminate risk of flood damage to real estate, improved real property, or structures with their contents.

(t) "Floodway" means the portion of the floodplain that is effective in carrying flow (that is, the channel of a river or other watercourse and the adjacent land areas that convey flood waters).

(u) "Government-sponsored flood control program to reduce risks to people, property, and State interests in the Delta" means any State or federal strategy, project, approval, funding, or other effort that is intended to reduce the likelihood and/or consequences of flooding of real property and/or improvements, including risks to people, property, and State interests in the Delta, that is carried out pursuant to applicable law, including, but not limited to the following:

(1) State Water Resources Law of 1945, Water Code section 12570 et seq.;

(2) Sacramento-San Joaquin River Flood Control Projects (Flood Control Act of 1941, P.L. 77-228);

(3) Local Plans of Flood Protection prepared pursuant to the Local Flood Protection Planning Act (Water Code section 8200 et seq.), that are consistent with the Central Valley Flood Protection Plan pursuant to Water Code section 9612;

(4) Central Valley Flood Protection Plan (Water Code section 9600 et seq.);

(5) Subventions Program, Special Projects Program (Water Code section 12300 et seq.);

(6) Way Bill 1973-Subventions Program, Special Projects Program (Water Code section 12980 et seq.);

(7) Central Valley Flood Protection Board Authority (California Code of Regulations, Title 23, Division 1); and

(8) National Flood Insurance Program (National Flood Insurance Act of 1968, 42 U.S.C. 4001 et seq., P.L. 90-448).

(v) "Nonnative invasive species," for purposes of section 5009, means species that establish and reproduce rapidly outside of their native range and may threaten the diversity or abundance of native species through competition for resources, predation, parasitism, hybridization with native populations, introduction of pathogens, or physical or chemical alteration of the invaded habitat.

(w) "Nonproject levee" means a local levee owned or maintained by a local agency or private owner that is not a project facility under the State Water Resources Law of 1945, Chapter 1 (commencing with Water Code section 12570) and Chapter 2 (commencing with section 12639 of Part 6 of the Water Code).

(x) "Project levee" means a federal flood control levee that is a project facility under the State Water Resources Law of 1945, Chapter 1 (commencing with Water Code section 12570) and Chapter 2 (commencing with section 12639 of Part 6 of the Water Code).

(y) "Proposed action" means a plan, program, or project that meets the covered action screening criteria listed in section 5001(j)(1)(A) through (D). Proposed action is also a "covered action," and therefore subject to compliance with the regulatory policies contained in Articles 2 and 3—if the proposed action meets the covered action screening criterion listed in section 5001(j)(1)(E).

(z) "Protection" or "protecting," for purposes of section 5001(h)(2), means preventing harm to the ecosystem, which could include preventing the conversion of existing habitat, the degradation of water quality, irretrievable conversion of lands suitable for restoration, or the spread of invasive nonnative species.

(aa) "Regulated stream" means those streams identified in Table 8.1 of California Code of Regulations, Title 23, section 112, under the jurisdiction of the Board.

(bb) "Restoration" or "restoring," for purposes of section 5001(h)(2), has the same meaning as in Water Code section 85066. Restoration actions may include restoring interconnected habitats within the Delta and its watershed, restoring more natural Delta flows, or improving ecosystem water quality.

(cc) "Setback levee" means a new levee constructed behind an existing levee which allows for removal of a portion of the existing levee and creation of additional floodplain connected to the stream. In the Delta, a "setback levee" may not necessarily result in removal of the existing levee.

(dd) "Significant impact" for the purpose of determining whether a project meets the definition of a "covered action" under section 5001(j)(1)(D) means a substantial positive or negative impact on the achievement of one or both of the coequal goals or the implementation of a government-sponsored flood control program to reduce risks to people, property, and State interests in the Delta, that is directly or indirectly caused by a project on its own or when the project's incremental effect is considered together with the impacts of other closely related past, present, or reasonably foreseeable future projects. The following categories of projects will not have a significant impact for this purpose:

(1) "Ministerial" projects exempted from CEQA, pursuant to Public Resources Code section 21080(b)(1);

(2) "Emergency" projects exempted from CEQA, pursuant to Public Resources Code section 21080(b)(2) through (4);

(3) Temporary water transfers of up to one year in duration. This provision shall remain in effect only through December 31, 2016, and as of January 1, 2017, is repealed, unless the Council acts to extend the provision prior to that date. The Council contemplates that any extension would be based upon the California Department of Water Resources' and the State Water Resources Control Board's participation with stakeholders to recommend measures to reduce procedural and administrative impediments to water transfers and protect water rights and environmental resources by December 31, 2016. These recommendations should include measures to address potential issues with recurring transfers of up to 1 year in duration and improved public notification for proposed water transfers;

(4) Other projects exempted from CEQA, unless there are unusual circumstances indicating a reasonable possibility that the project will have a significant impact under Water Code section 85057.5(a)(4), as further defined by this section. Examples of unusual circumstances could arise in connection with, among other things:

(A) Local government general plan amendments for the purpose of achieving consistency with the Delta Protection Commission's Land Use and Resource Management Plan; and,

(B) Small-scale habitat restoration projects, as referred to in CEQA Guidelines, section 15333 of Title 14 of the California Code of Regulations, proposed in important restoration areas, but which are inconsistent with the Delta Plan's policy related to appropriate habitat restoration for a given land elevation (section 5006 of this Chapter).

(ee) "Urban area" means a developed area in which there are 10,000 residents or more.

(ff) "Urbanizing area" means a developed area or an area outside of a developed area that is planned or anticipated to have 10,000 residents or more within the next 10 years.

(gg) "Urban water management plan" means a plan prepared, adopted, and updated by an urban water supplier pursuant to the Urban Water Management Planning Act, Water Code section 10610 et seq.

(hh) "Urban water supplier" refers to both "urban retail water suppliers" and "urban wholesale water suppliers":

(1) "Urban retail water supplier" means a water supplier, either publicly or privately owned, that directly provides potable municipal water to more than 3,000 end users or that supplies more than 3,000 acre-feet of potable water annually at retail for municipal purposes.

(2) "Urban wholesale water supplier" means a water supplier, either publicly or privately owned, that provides more than 3,000 acre-feet of potable water annually at wholesale for municipal purposes.

(ii) "Water supplier" refers to both "urban water suppliers" and "agricultural water suppliers," but for purposes of section 5003, does not include agricultural water suppliers during the time that they may be exempted by section 10853 of the Water Code from the requirements of Parts 2.55 and 2.8 of Division 6 of the Water Code.

23 CCR Section 5001
NOTE: Authority cited: Section 85210(i), Water Code.
Reference: Sections 85057.5, 85059, 85058, 85066, 85020, 85054, 85052, 85302(g), 85308, 85300, 10608.12, and 10853, Water Code.

Key Terms, Acronyms, and Abbreviations Used in the Delta Plan

Term	Definition
100-year flood	A flood event having a 1-in-100 chance of being equaled or exceeded in any given year.
200-year flood	A flood event having a 1-in-200 chance of being equaled or exceeded in any given year.
AB	Assembly Bill
acre-foot	The volume of water that would cover 1 acre of land to a depth of 1 foot; equal to 43,560 cubic feet or 325,851 gallons.
accommodation space	The space in the Delta that lies below sea level and is filled with neither sediment nor water.
Act	See Sacramento-San Joaquin Delta Reform Act of 2009
ACWA	Association of California Water Agencies
administrative procedure	Procedures adopted by the Delta Stewardship Council (Council), in accordance with Water Code section 85225.30, that govern how the Council considers appeals with respect to the following: (1) Adequacy of certifications of consistency with the Delta Plan submitted to the Council by a State or local agency pursuant to Water Code section 85225.10, and (2) Determinations by the California Department of Fish and Wildlife that the Bay Delta Conservation Plan has met the requirements of Water Code section 85320 for inclusion in the Delta Plan.
advanced treatment	Any treatment of sewage that goes beyond the secondary or biological water treatment stage and includes the removal of nutrients, including phosphorus, nitrogen, and a high percentage of suspended solids.
Aeration Facility	Demonstration Dissolved Oxygen Aeration Facility
agricultural water use	Water used for farming, horticulture, or ranching including irrigation, stock watering, or support of vegetation for range grazing. This includes water used for irrigation and nonirrigation purposes. Irrigation water use includes the artificial application of water on land to promote the growth of crops and pasture, or to maintain vegetative growth in recreational lands, parks, and golf courses. Nonirrigation water use includes water used for livestock, which includes water for stock watering, feedlots, and dairy operations, and fish farming and other farm requirements.
agricultural water use efficiency	Defined by California Department of Water Resources as the ratio of applied water to the amount of water required to sustain agricultural productivity. Efficiency is increased through the application of less water to achieve the same beneficial productivity or by achieving more productivity while applying the same amount of water.
AGWA	Association of Groundwater Agencies
anadromous fish	Fish that are born in fresh water, migrate to the ocean to mature, and then return to fresh water to spawn.

Term	Definition
anticipated future stressors	Stressors that require preparation and planning for mitigation in advance of their onset (for example, future land subsidence, urban expansion, and new invasions by nonnative species).
artesian water	A groundwater aquifer under positive pressure. In some cases, the hydrostatic equilibrium elevation of the groundwater is higher than the elevation of the surrounding ground surface. When an artesian aquifer is penetrated by a well, the water level will rise above the top of the aquifer, and even flow out of the ground.
AWWA	American Water Works Association
BAFF	bio-acoustic fish fence
base camp	A park, resort, or town that provides services (for example, park rangers, interpretation, and boat rentals) and facilities (for example, parking, restrooms, picnic sites, boat ramps, and campgrounds). The mix of facilities is determined by adjacent recreation opportunities and nearby public and private facilities.
basin plan	A water quality control plan for a specific basin or region in California. It includes a comprehensive program of actions designed to preserve, enhance, and restore water quality in that basin. The basin plan is the master water quality control planning document for the regional boards. It describes beneficial uses of surface water and groundwater, and establishes water quality objectives to protect those uses.
Bay Plan	San Francisco Bay Plan
Bay-Delta Plan	Bay-Delta Water Quality Control Plan
BCDC	San Francisco Bay Conservation and Development Commission
BDCP	Bay Delta Conservation Plan
beneficial uses	Uses of the waters of the state that include domestic, municipal, agricultural, and industrial supply; power generation; recreation; aesthetic enjoyment; navigation; and preservation and enhancement of fish, wildlife, and other aquatic resources or preserves.
beneficiaries	Entities that benefit from using the resources of the Delta, including water supply, conveyance, and recreation.
benthic	The collection of organisms living on or in sea, lake, or river bottoms.
best management practices (BMPs)	Methods or techniques found to be the most effective and practical means of achieving an objective, such as water conservations. BMPs include, but are not limited to, structural and nonstructural controls, and operation and maintenance procedures. Examples of water conservation BMPs include tiered rate structures and water-efficient plumbing and irrigation systems.
bioaccumulation	The process by which a chemical is taken up by an aquatic organism, both from direct exposure to water and through the consumption of food containing the chemical.
biological opinion	A document stating the opinion of the U.S. Fish and Wildlife Service or the National Marine Fisheries Service as to whether or not federal action is likely to jeopardize the continued existence of a threatened or endangered species, or result in the destruction or adverse modification of critical habitat.

Term	Definition
biomagnify, biomagnification	The sequence of processes in an ecosystem by which higher concentrations of a particular chemical, a pesticide for example, are reached in organisms higher up the food chain, generally through a series of prey-predator relationships.
BMP	See best management practices
bypass	An area of land or a large, constructed structure designed to convey excess floodwaters from a river or stream in order to reduce the risk of flooding on the natural river or stream near a city or other population center.
Cal EMA	California Emergency Management Agency
Caltrans	California Department of Transportation
CARB	California Air Resources Board
carbon sequestration	The process of removing carbon from the atmosphere and storing it. Trees and plants, for example, absorb carbon dioxide, release the oxygen, and store the carbon in their biomass. The stored biomass may eventually turn to peat, other soil-borne organic matter, and fossil fuels such as coal or petroleum that will continue to store the carbon until the fuels are burned.
CASGEM	California Statewide Groundwater Elevation Monitoring Program
CCR	*California Code of Regulations*
CDFA	California Department of Food and Agriculture
centrarchids	Small, carnivorous, freshwater, spiny-finned fishes of North America usually having a laterally compressed body and metallic luster (for example, largemouth bass, smallmouth bass, spotted bass, bluegill, warmouth, redear sunfish, green sunfish, white crappie, and black crappie).
certification of consistency	The written certification to the Delta Stewardship Council, with detailed findings, that a covered action is consistent with the Delta Plan. Certifications of consistency are submitted to the Delta Stewardship Council by the State or local agency that is proposing to carry out, fund, or approve a covered action under the California Environmental Quality Act (Water Code section 85225 et seq.).
CEQA	California Environmental Quality Act
cfs	cubic feet per second
channelization	(1) Natural or intentional straightening and deepening of streams through dredging or construction of levees. (2) A marsh-drainage tactic that can disturb fish and wildlife habitats, aggravate flooding, and decrease the capacity to absorb pollution without suffering damage.
climate change	Any significant change in measures of climate (such as temperature, precipitation, or wind) lasting for an extended period (decades or longer). Climate change may result from (1) natural factors, including changes in the sun's intensity or changes in the Earth's orbit around the sun, (2) natural processes within the climate system (such as changes in ocean circulation), or (3) human activities that change the composition of the atmosphere (for example, through burning fossil fuels) and land surfaces (for example, deforestation, reforestation, urbanization, and desertification).

Term	Definition
CNDDB	California Natural Diversity Database
CNPS	California Native Plant Society
CNRA	California Natural Resources Agency
CO_2	carbon dioxide
COA	Coordinated Operating Agreement
conceptual model	An explicit description of mental models, knowledge, and hypotheses about the structure and function of a system or process.
conjunctive management	The coordinated and planned management of both surface water and groundwater resources to maximize efficient water use. Water is stored in groundwater basins for future use by intentionally recharging the basin during years of above-average surface water supply. Surface water and groundwater resources typically differ significantly in their availability, quality, management requirements, and development and use costs. Managing both resources together, rather than in isolation from one another, allows water managers to use the advantages of both resources for maximum benefit.
conveyance	The movement of water from one place to another. Conveyance infrastructure includes natural watercourses as well as canals, pipelines, and control structures including weirs. Examples of natural watercourses include streams, rivers, and groundwater aquifers. Conveyance facilities range in size from small, local, end-user distribution systems to large systems that deliver water to or drain areas covering multiple hydrologic regions. Conveyance facilities require associated infrastructure including pumping plants, power supply, diversion structures, fish ladders, and fish screens.
Council	Delta Stewardship Council
critical habitat	Specific areas, both occupied and unoccupied, that are essential to the conservation of a listed species and that may require special management considerations or protection (as defined in Section 3 of the federal Endangered Species Act).
current stressors	Stressors that result from ongoing human activities that can, in some cases, be eliminated (for example, fish entrainment at water diversions).
CVFPB	Central Valley Flood Protection Board
CVFPP	Central Valley Flood Protection Plan
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
CV-SALTS	Central Valley Salinity Alternatives for Long-Term Sustainability Program
CWA	Clean Water Act
CZMA	Coastal Zone Management Act of 1972
DBW	California Department of Boating and Waterways
DDT	dichlorodiphenyltrichloroethane

Term	Definition
dedicated (or developed) water	Defined by California Department of Water Resources (DWR) as water distributed among urban and agricultural uses, used for protecting and restoring the environment, or storage in surface water and groundwater reservoirs. In any year, some of the dedicated supply includes water that is used multiple times (reuse) and water that is held in storage from previous years. DWR identifies California's average annual dedicated water supply as 85 million acre-feet. *See also: total water use.*
Delta	Sacramento-San Joaquin Delta
Delta Conservancy	Sacramento–San Joaquin Delta Conservancy
Delta Ecological Management Zone	The Delta conservation strategy adopted by the Department of Fish and Wildlife as the *Ecosystem Restoration Program Conservation Strategy for Restoration of the Sacramento-San Joaquin Delta Ecological Management Zone and the Sacramento and San Joaquin Valley Regions.*
Delta exports	Describes, in general terms, any water diverted from the Delta for use outside the Delta, including water pumped by the State Water Project and Central Valley Project pumping plants, Contra Costa Water District, and other agencies. The term must be precisely defined when applied to specific studies or analyses.
Delta Flood Risk Management Assessment District	As proposed in the Delta Plan, an assessment district authorized to set fees on State and local infrastructure to generate funds for levee maintenance and surveys; adequate flood control protection; and emergency response for the benefit of landowners, infrastructure owners, and other entities that benefit from the maintenance and improvement of Delta levees, including water users who rely on the levees to protect water quality.
Delta Independent Science Board (Delta ISB)	Established by the Sacramento-San Joaquin Delta Reform Act of 2009, the Delta ISB is a standing board of nationally and internationally prominent scientists with appropriate expertise to evaluate the broad range of scientific programs that support adaptive management of the Delta. The Delta ISB will provide oversight of the scientific research, and monitoring and assessment programs that support adaptive management of the Delta through periodic reviews of each of those programs. The overall objective of Delta ISB oversight is to help make the science underlying Bay-Delta programs, the application of that science, and the technical aspects of those programs the best they can be (Water Code section 85280 et seq.).
Delta ISB	See Delta Independent Science Board
Delta Levee Special Flood Control Projects	A California Department of Water Resources program, authorized in Water Code sections 12300 through 12314, that provides financial assistance to local levee-maintaining agencies for rehabilitating levees in the Delta.
Delta Multi-Hazard Coordination Task Force	A task force established to address emergency preparedness and response issues in the Delta by enabling the development and implementation of multi-hazard preparedness and response strategies for the Delta. Led by the California Emergency Management Agency (Cal EMA), the task force consisted of representatives from the Delta Protection Commission, California Department of Water Resources, and representatives of the five Delta counties. The passage of Senate Bill 27 in 2008 required Cal EMA, formerly the Office of Emergency Services, to establish the task force.

Term	Definition
Delta Primary Zone	The Sacramento-San Joaquin River Delta land and water area of primary State concern and statewide significance that does not encompass either the urban limit line or sphere of influence line of any local government general plan or study existing as of January 1, 1992. The precise boundary lines of the Primary Zone include the land and water areas as shown on the map titled "Delta Protection Zones" on file with the California State Lands Commission. Where the boundary between the Primary Zone and Secondary Zone is a river, stream, channel, or waterway, the boundary line is the middle of that river, stream, channel, or waterway. The Primary Zone consists of approximately 500,000 acres (Public Resources Code section 29728).
Delta Reform Act	See Sacramento-San Joaquin Delta Reform Act of 2009
Delta Secondary Zone	All the Delta land and water area within the boundaries of the Delta not included within the Primary Zone, subject to the land use authority of local government, and that includes the land and water areas as shown on the map titled "Delta Protection Zones" on file with the State Lands Commission. The Secondary Zone consists of approximately 238,000 acres (Public Resources Code section 29731).
Delta Vision	Delta Vision Blue Ribbon Task Force
Delta watershed	The watershed of the Sacramento River Hydrologic Region and the San Joaquin River Hydrologic Region as described in the California Water Plan Update 2005, Bulletin 160-05 (Water Code section 85060).
demand management measures	Water conservation measures, programs, and incentives that prevent the waste of water and promote the reasonable use and reuse of available supplies.
desalination	A water treatment process for the removal of salt from water for beneficial use. Source water can be brackish (low salinity) or sea water.
DFG	California Department of Fish and Game
DFW	California Department of Fish and Wildlife (formerly the California Department of Fish and Game)
diversion	A process which, having return flow and consumptive use elements, turns water from a given path. Removal of water from its natural channel for human use. Use of part of a streamflow as a water supply. Channel constructed across the slope for the purpose of intercepting surface runoff, changing the accustomed course of all or part of a stream. A structural conveyance (or ditch) constructed across a slope to intercept runoff flowing down a hillside and divert it to some convenient discharge point.
DO	dissolved oxygen
DOC	California Department of Conservation
DPC	Delta Protection Commission
DPH	California Department of Public Health
DRERIP	Delta Regional Ecosystem Restoration Implementation Plan
drinking water quality	Drinking water quality standards are adopted by the California Department of Public Health (DPH) Drinking Water Program pursuant to the California Safe Drinking Water Act. The standards apply to public drinking water systems and to water delivered to customers, and are enforceable by DPH and local health departments.

Term	Definition
drought	Hydrologic conditions during a defined period, greater than 1 dry year, when precipitation and runoff are much less than average.
DWR	California Department of Water Resources
DWR 200 Year	DWR 200-year Urban Levee Protection
EAD	See expected annual damage
ecosystem	A biotic community and its physical environment, considered as an integrated unit. Implied within this definition is the concept of a structural and functional whole unified through life processes. An ecosystem may be characterized as a viable unit of community and interactive habitat. Ecosystems are hierarchical and can be viewed as nested sets of open systems in which physical, chemical, and biological processes form interactive subsystems. Some ecosystems are microscopic, and the largest comprises the biosphere. Ecosystem restoration can be directed at different-sized ecosystems within the nested set, and many encompass multiple states, more localized watersheds, or a smaller complex of aquatic habitat.
ecosystem enhancement	The improvement of existing desirable habitat and natural processes. Enhancement might include flooding the Yolo Bypass more often, at times, to support native species, or expand or better connect existing habitat areas. Enhancement also includes many fish and wildlife management practices, including managing wetlands for waterfowl production or shorebird habitat, installing fish screens to reduce entrainment of fish at water diversions, or removing barriers that block migration of fish to upstream spawning habitats.
ecosystem protection	Preventing harm to an ecosystem, which could include preventing the conversion of existing habitat, the degradation of water quality, irretrievable conversion of lands suitable for restoration, or the spread of invasive nonnative species.
ecosystem restoration	The application of ecological principles to restore a degraded or fragmented ecosystem and return it to a condition in which its biological and structural components achieve a close approximation of its natural potential, taking into consideration the physical changes that have occurred in the past and the future impact of climate change and sea level rise (Water Code section 85066).
Ecosystem Restoration Program Conservation Strategy	Describes the Ecosystem Restoration Program (ERP) priorities and actions for Stage 2 of the CALFED Bay-Delta Program (summarized in Appendix B). It identifies biologically promising ecosystem restoration opportunities in the Sacramento-San Joaquin Delta Ecological Management Zone and the Sacramento Valley and San Joaquin Valley regions, and it provides the rationale for restoration actions specific to each of these regions. It further provides the conceptual framework and process to guide the refinement, evaluation, prioritization, implementation, monitoring, and review of ERP actions.
ecosystem water quality	The Delta ecosystem is affected by a variety of pollutants discharged into Delta and tributary waters. Pollutants of concern affecting Delta biological species and ecosystem processes include nutrients, pesticides, mercury, selenium, and other persistent bioaccumulative toxic substances. Newly identified pollutants of potential concern (often referred to as emerging contaminants) also should be investigated.
EIR	environmental impact report

Term	Definition
endangered species	As defined by the California Endangered Species Act, an endangered species is a native species or subspecies of a bird, mammal, fish, amphibian, reptile, or plant that is in serious danger of becoming extinct throughout all, or a significant portion, of its range due to one or more causes, including loss of habitat, change in habitat, overexploitation, predation, competition, or disease. Any species determined by the Fish and Game Commission as endangered on or before January 1, 1985, is an endangered species (Fish and Game Code section 2062).
entrainment	Defined by the National Marine Fisheries Service as "the incidental trapping of any life stage of fish within waterways or structures that carry water being diverted for anthropogenic use."
environmental water	Minimum flow levels of a specific quality that are needed in order to assure the continued viability of fish and wildlife resources for a particular water body. This water is used to maintain and enhance the beneficial uses related to the preservation and enhancement of fish, wildlife, and other aquatic resources or preserves as specified in the Porter-Cologne Water Quality Control Act.
environmental water use	Water dedicated to instream environmental needs.
EPRRP	Emergency Preparedness Response and Recovery Program
ERP	Ecosystem Restoration Program
ESA	Endangered Species Act
ESP	The Delta Protection Commission's *Economic Sustainability Plan for the Sacramento-San Joaquin Delta*
estuary	A place where fresh and salt water mix, such as a bay, salt marsh, or where a river enters an ocean.
expanded water supply reliability element	Additional information water suppliers should include in their water supply reliability element, starting in 2015, as part of the update of any urban water management plan, agricultural water management plan, integrated water management plan, or other plan that provides equivalent information on the supplier's planned investments in water conservation and water supply development. This expanded water supply reliability element must detail how water suppliers are improving regional self-reliance and reducing reliance on the Delta through investments in local and regional programs and projects, and must document actual and projected reductions in reliance on Delta exports. At a minimum, the water reliability element must include the following: (1) A plan for possible interruption of Delta water supply due to catastrophic events. (2) A plan for implementation of anticipated investments in water conservation, water efficiency, and water supply development. (3) Evaluation of regional water balance. (4) Conservation-oriented water rate structure.
expected annual damage (EAD)	A metric for analyzing flood risk that integrates the likelihood and consequences of flooding. Generally defined as the average annual flood damages (in dollars) weighted by the probability that a flood will occur in any given year. The U.S. Army Corps of Engineers describes EAD mathematically in *Manual No. 1110-2-1619, Risk-Based Analysis for Flood Damage Reduction Studies*, August 1, 1996.
FEMA	Federal Emergency Management Agency
FEMA 100 Year	FEMA 100-year (Base Flood) Protection

Term	Definition
flood risk	The likelihood and consequence of inundation by floodwaters. Consequences may include direct or indirect economic costs, loss of life, environmental impacts, or other specified measures of flood effect. Flood risk is a function of (1) loading, which is the frequency and magnitude of flood discharge or stage; (2) limits to exposure to the loading due to flood defense measures; and (3) consequence. Therefore, flood management actions may reduce risk by changing loading, exposure, or consequence. For clarity, flood risk is commonly quantified within an identified area for a specified climate condition, land use condition, and with a flood management system (existing or planned) in place.
flow criteria	The development of specific criteria by the State Water Resources Control Board for flows for the Delta ecosystem, including the volume, quality, and timing of water necessary for the Delta ecosystem under different conditions (Water Code section 85086(c)(1)).
flow objectives	Where protection of beneficial uses requires specific flow volumes at certain times, regional water quality control boards may establish flow objectives in water quality control plans. They differ from typical water quality objectives in that they are implemented by the State Water Resources Control Board through modifications and limitations of existing or future water rights to make sure these flows are met.
flow regime	The regulation of ecological processes in river ecosystems: the magnitude, frequency, duration, timing, and rate of change of hydrologic conditions (Poff and Ward 1989, Richter et al. 1996, Walker 1995). These components can be used to characterize the entire range of flows and specific hydrologic phenomena, including floods or low flows, that are critical to the integrity of river ecosystems. Furthermore, by defining flow regimes in these terms, the ecological consequences of particular human activities that modify one or more components of the flow regime can be considered explicitly.
flow requirements	The amount of water required for instream use by agreement, water rights permit, or State/federal law.
freeboard	The height of the physical top of a levee or floodwall above the median design water surface elevation.
gateway	A community, landmark, or signage on the edge of the Delta or Suisun Marsh that serves as a gateway providing information to visitors about recreation opportunities available in the area and equipping them with supplies.
general obligation bond	A bond issued by the State where the principal and interest is paid out of the General Fund. This is different than a revenue bond, where the principal and interest is paid out of a specific dedicated revenue source.
globally determined stressors	Stressors that result from large-scale human activities or natural processes that cannot be eliminated or mitigated within a limited purview and require larger-scale planning and adaptation (such as global climate change and human population growth).
GPCD	gallons per capita daily
groundwater basin	An alluvial aquifer or a stacked series of alluvial aquifers with reasonably well-defined boundaries in a lateral direction and having a definable bottom.
groundwater management plan	A comprehensive written document developed for the purpose of groundwater management and adopted by an agency having appropriate legal or statutory authority.

Term	Definition
groundwater overdraft	The condition of a groundwater basin in which the amount of water withdrawn by pumping exceeds the amount of water that recharges the basin over a period of years during which water supply conditions approximate average conditions.
groundwater remediation	The extraction of contaminated groundwater from an aquifer followed by treatment and (1) replacement in the aquifer or (2) use for agricultural or municipal purposes.
groundwater storage	Defined three ways depending on the context: (1) the quantity of water beneath the land surface that fills the pore spaces of the alluvium, soil, or rock formation; (2) the volume of usable physical space available to store water in the pore spaces of the alluvium, soil, or rock formation beneath the land surface; or (3) the act of storing water in the pore spaces of the alluvium, soil, or rock formation beneath the land surface.
HAB	harmful algal bloom
habitat	The location and the living and nonliving surroundings where a particular plant or animal lives. Habitat includes the presence of a group of particular environmental conditions surrounding an organism including air, water, soil, mineral elements, moisture, temperature, and topography.
Habitat Conservation Plan (HCP)	A plan prepared under the Endangered Species Act by nonfederal parties in order to obtain permits for incidental taking of threatened and endangered species. The HCP describes ways to maintain, enhance, and protect a given habitat type needed to protect species. The plan usually includes measures to minimize impacts, and might include provisions for permanently protecting land, restoring habitat, and relocating plants or animals to another area.
habitat restoration	The manipulation of the physical, chemical, or biological characteristics of a site with the goal of returning the majority of natural functions to the lost or degraded native habitat.
Hazard Mitigation Plan (HMP)	Refers to levee guidance negotiated between various federal, State, and local agencies to assist in reducing the likelihood of repetitive flood damage to Delta levees and islands. This guidance provides geometric levee design criteria that, if maintained, make a Delta levee-maintaining agency eligible for federal disaster assistance funds in the event of a flood emergency.
HCP	See Habitat Conservation Plan
HGMP	Hatchery and Genetic Management Plans
HMP	See Hazard Mitigation Plan
hydraulic mining	The use of high-pressure jets of water to dislodge rock material or move sediment.
hydrodynamics	The description of the change in flow or motion of a liquid.
hydrologic region	A geographical division of the state based on local hydrologic basins. The California Department of Water Resources divides California into 10 hydrologic regions, corresponding to the state's major water drainage basins: North Coast, San Francisco Bay, Central Coast, South Coast, Sacramento River, San Joaquin River, Tulare Lake, North Lahontan, South Lahontan, and Colorado River.
IEP	Interagency Ecological Program
incidental take permit	A permit issued by federal fisheries agencies that authorizes take of listed species incidental to otherwise lawful projects.

Term	Definition
instream flow	The use of water within its natural watercourse as specified in a contract, a water rights permit, a court order, a Federal Energy Regulatory Commission license, or other documentation. Instream flows support natural ecosystems, create habitat for plants and animals, and may provide additional benefits including recreation. *See also: flow requirements*.
integrated regional water management	A collaborative effort to manage all aspects of water resources in a specified region. Integrated regional water management crosses jurisdictional, watershed, and political boundaries; involves multiple agencies, stakeholders, individuals, and groups; and attempts to address the issues and differing perspectives of all entities involved through mutually beneficial solutions.
integrated regional water management plan (IRWMP)	At a minimum, an integrated regional water management plan describes the major water-related objectives and conflicts within a region; considers a broad variety of water management strategies; identifies an appropriate mix of water demand and supply management alternatives; provides water quality protections and environmental stewardship actions to provide a long-term, reliable, and high-quality water supply; protects the environment; and identifies disadvantaged communities in the region taking into account the water-related requirements of those communities.
invasive species	An alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health (Executive Order 13112, 1999).
land reclamation	The process to recover land through channelization and levee construction of what was previously marsh land.
IRWMP	See integrated regional water management plan.
LADWP	Los Angeles Department of Water and Power
LAEDC	Los Angeles Economic Development Corporation
LAO	California Legislative Analyst's Office
legacy community	A rural community registered as a Historic District by either a State or federal entity. Delta legacy communities include Bethel Island, Clarksburg, Courtland, Freeport, Hood, Isleton, Knightsen, Rio Vista, Ryde, Locke, and Walnut Grove (Public Resources Code section 32301(f)).
legacy stressors	Stressors that result from past actions that cannot be undone, but whose impact can sometimes be reduced or mitigated (for example, mercury pollution from historical gold mining).
Legislature	California Legislature
levee-maintaining agencies	Local special districts, typically reclamation districts, that are public agencies formed for the purpose of levee maintenance and improvement, among other duties, and are funded by local assessments.
levee standards	Standards designed to either establish minimum criteria that would make levees and the properties protected eligible for Federal Emergency Management Agency (FEMA) grants or U.S. Army Corps of Engineers (USACE) rehabilitation funds both in case of catastrophic emergency, or set minimum criteria that would allow development behind the levees. The four main applicable levee standards and guidance for the Delta are (1) FEMA Hazard Mitigation Plan Guidance, (2) USACE Public Law 84-99, (3) FEMA 100-year (Base Flood) Protection, and (4) DWR 200-year Urban Levee Protection.
LHC	Little Hoover Commission

Term	Definition
low salinity zone (LSZ)	Generally, the region in an estuary with salinity ranging from fresh water up to about 5 parts per thousand (ppt), about one-seventh the salinity of sea water. The part of the salinity gradient centered on 2 ppt is considered to be of particular importance because it is hypothesized to be an area where suspended particulate matter and organisms accumulate. The location in the Bay-Delta where the tidally averaged salinity at 1 meter from the bottom is 2 ppt is known as X2 (measured as distance in kilometers from the Golden Gate Bridge) and serves as a water quality objective regulating Delta outflow.
LPP	Suisun Marsh Local Protection Program
LSZ	See low salinity zone
LTMS	Delta Dredged Sediment Long-Term Management Strategy
µS/cm	microsiemens per centimeter
MAF	million acre-feet
managed wetland	Perched wetlands that receive human-induced seasonal flooding for marshland development.
MCL	maximum contaminant level
mg/L	milligram(s) per liter
MWD	Metropolitan Water District of Southern California
NAS	National Academy of Sciences
National Heritage Area (NHA)	Places designated by the United States Congress where natural, cultural, historic, and recreational resources combine to form a cohesive, nationally distinctive landscape arising from patterns of human activity shaped by geography. These areas tell important stories about the nation and are representative of the national experience through both the physical features that remain and the traditions that have evolved within them.
National Pollutant Discharge Elimination System (NPDES)	A permitting program required for all point sources discharging pollutants into waters of the United States. The purpose of the NPDES program is to protect human health and the environment (Clean Water Act of 1977, 33 United States Code section 1311).
Natural Community Conservation Plan (NCCP)	A conservation plan created to meet the requirements of the Natural Community Conservation Planning Act, which identifies and provides for the regional or areawide protection of plants, animals, and their habitats, while allowing compatible and appropriate economic activity. The primary objective of the NCCP program is to conserve natural communities at the ecosystem level while accommodating compatible land use (Fish and Game Code section 2800 et seq.).
NCCP	See Natural Community Conservation Plan
new water	Defined in part by California Department of Water Resources as water that is legally and empirically available for a beneficial use. New water can be developed through many strategies such as capturing surplus water, desalinating ocean water, and improving water efficiency.
NHA	See National Heritage Area
NMFS	National Marine Fisheries Service

Term	Definition
nonpoint source pollution	Diffused sources that do not have a single point of origin or are not introduced into a receiving stream from a specific outlet. The pollutants are generally carried off the land by stormwater runoff. Common categories of nonpoint sources are agriculture, forestry, mining, construction, land disposal, and salt intrusion.
NPDES	See National Pollutant Discharge Elimination System
NRC	National Research Council
NWR	National Wildlife Refuge
OP	organophosphorus
OPC	California Ocean Protection Council
Paterno v. State of California	In *Paterno v. State of California*, the appellate court found the State liable for flood-related damages caused by the failure of a Yuba River levee incorporated into the State system of flood control, even though the State did not design, build, or even directly maintain it (*Paterno v. State* [2003] 113 Cal. App.4th 998 [6 Cal.Rptr.3d 854]).
PCB	polychlorinated biphenyl
peak flow	Maximum instantaneous flow in a specified period.
pelagic fish	A fish species that spends most of its life swimming in the water column with little contact with or dependency on the bottom. Adult spawning usually occurs in open water, often near the surface.
pelagic organism decline (POD)	A steep decline leading to near-record low populations of four pelagic species in the San Francisco Estuary—delta smelt, young striped bass, longfin smelt, and threadfin shad—widely recognized as a serious issue by 2004.
performance measures	A quantitative or qualitative tool to assess progress toward an outcome or goal. The Delta Plan must include performance measurements that will enable the Delta Stewardship Council to track progress in meeting the objectives of the Plan. Performance measurements must include, but need not be limited to, quantitative or otherwise measurable assessments of the status and trends in all of the following: (1) The health of the Delta estuary and wetland ecosystem for supporting viable populations of aquatic and terrestrial species, habitats, and processes including viable populations of Delta fisheries and other aquatic organisms. (2) The reliability of California water supply imported from the Sacramento River or the San Joaquin River watershed.
PL 84-99	See Public Law 84-99
Plan	Delta Plan
POD	See pelagic organism decline

Term	Definition
point source	Any discernible, confined, and discrete conveyance including, but not limited to, any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, landfill leachate collection system, vessel, or other floating craft from which pollutants are or may be discharged. This term does not include return flows from irrigation agriculture or agricultural stormwater runoff (40 *Code of Federal Regulations* 122.2).
pollutant	Defined as "dredged spoil, solid waste, incinerator residue, filter backwash, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt and industrial, municipal, and agricultural waste discharged into water" (Clean Water Act of 1977, 33 United States Code section 1362(6)).
pollution	Defined as the human-made or human-induced alteration of the chemical, physical, biological, and radiological integrity of water (Clean Water Act section 502(19); 33 United States Code section 1362(19)). Pollution is also defined in California law as an alternation of the quality of the waters of the state by waste to a degree that unreasonably affects either the waters for beneficial uses or the facilities that serve these beneficial uses (Water Code section 13050(k)(1)).
ppb	parts per billion
PPIC	Public Policy Institute of California
ppm	parts per million
ppt	parts per thousand
PRBO CalPIF	Point Reyes Bird Observatory California Partners in Flight
Public Law 84-99 (PL 84-99)	A federal levee standard developed by the U.S. Army Corps of Engineers (USACE). Meeting this standard allows the Delta island or tract to be eligible for USACE funding for levee rehabilitation, island restoration after levee failures, and island inundation, provided that the reclamation district applies for and is accepted into the USACE's Rehabilitation and Inspection Program.
Public Trust Doctrine	This doctrine protects the right of the public to use State sovereign lands and waters for commerce, navigation, hunting, fishing, bathing, swimming, boating, and general recreational purposes, and also protects trust lands and waters in their natural state, so that they may serve as ecological units for scientific study, as open space, and as environments that provide food and habitat for birds and marine life, and which favorably affect the scenery and climate of the area. There is also a separate branch of the Public Trust Doctrine that protects the fishery resources in all State waters, including those in nonnavigable waterways, as public trust resources in and of themselves.

Term	Definition
Reasonable and Beneficial Use Doctrine	This doctrine states that a water right does not include the right to waste water and mandates that the water resources of the state be put to beneficial use. "It is hereby declared that because of the conditions prevailing in this State the general welfare requires that the water resources of the State be put to beneficial use to the fullest extent of which they are capable, and that the waste or unreasonable use or unreasonable method of use of water be prevented, and that the conservation of such waters is to be exercised with a view to the reasonable and beneficial use thereof in the interest of the people and for the public welfare. The right to water or to the use or flow of water in or from any natural stream or water course in this State is and shall be limited to such water as shall be reasonably required for the beneficial use to be served, and such right does not and shall not extend to the waste or unreasonable use or unreasonable method of use or unreasonable method of diversion of water. Riparian rights in a stream or water course attach to, but to no more than so much of the flow thereof as may be required or used consistently with this section, for the purposes for which such lands are, or may be made adaptable, in view of such reasonable and beneficial uses; provided, however, that nothing herein contained shall be construed as depriving any riparian owner of the reasonable use of water of the stream to which the owner's land is riparian under reasonable methods of diversion and use, or as depriving any appropriator of water to which the appropriator is lawfully entitled. This section shall be self-executing, and the Legislature may also enact laws in the furtherance of the policy in this section contained" (California Constitution Article X section 2).
reasonable and prudent alternative	The regulations implementing Section 7 of the Endangered Species Act define reasonable and prudent alternatives as alternative actions, identified during formal consultation, that (1) can be implemented in a manner consistent with the intended purpose of the action, (2) can be implemented consistent with the scope of the action agency's legal authority, (3) are economically and technologically feasible, and (4) would, according to the National Marine Fisheries Service, avoid the likelihood of jeopardizing the continued existence of listed species and avert the destruction or adverse modification of critical habitat (Endangered Species Act of 1973, 16 United States Code section 1536).
Reclamation	Bureau of Reclamation
Recreation Proposal	*Recreation Proposal for the Sacramento-San Joaquin Delta and Suisun Marsh*
regional self-reliance	The degree to which a region implements water management options so that it can provide for all of its needs for water from within its own borders.
regional water supplies	Water supplies that are found or developed within a region to be used within its own borders.
reservoir reoperation	Changes to existing operations and management procedures for existing reservoirs and conveyance facilities to increase water-related benefits from these facilities.
resource management strategy	A project, program, or policy that helps federal, State, or local agencies manage water and related resources. Resource management strategies in the California Water Plan are grouped by intended outcomes: reduce water demand, improve operational efficiency and transfers, increase water supply, improve water quality, practice resource stewardship, and improve flood management. Although most of the resource management strategies have multiple potential benefits, any individual site-specific project or program within a resource management strategy may contribute only one, or a few, of the benefits.
riparian area	The land adjacent to a natural watercourse such as a river or a stream. Riparian areas support vegetation that provides important wildlife habitat and important fish habitat when shading the watercourse bank.

Term	Definition
RWCF	Stockton Regional Wastewater Control Facility
RWQCB	Regional Water Quality Control Board
SACOG	Sacramento Area Council of Governments
Sacramento-San Joaquin Delta Reform Act of 2009 (Delta Reform Act or Act)	Included in Senate Bill X71, established a new governance approach for the Sacramento-San Joaquin Delta that is focused on achieving the coequal goals and is fundamentally different from past approaches. The Delta Reform Act created the Delta Stewardship Council and gave it the direction and authority to serve two primary governance roles: (1) set a comprehensive, legally enforceable direction for how the State manages important water and environmental resources in the Delta through the adoption of a Delta Plan, and (2) ensure coherent and integrated implementation of that direction through coordination and oversight of State and local agencies proposing to fund, carry out, and approve Delta-related activities.
Safe Harbor Agreement	A voluntary agreement made between wildlife agencies and landowners in order to recover a listed species.
SAV	submerged aquatic vegetation
SB	Senate Bill
SBX7 1	Senate Bill X7 1
SBX7 7	Senate Bill X7 7
SDWSC	Stockton Deep Water Ship Channel
sea level rise	A change in average global sea level caused by a change in ocean volume. Often discussed in relation to climate change.
seepage	Percolation of water through the soil from unlined canals, ditches, laterals, watercourses, or water storage facilities.
SEMS	See Standardized Emergency Management System
sensitive species	Species not yet officially listed but undergoing status review for listing on the U.S. Fish and Wildlife Service's official threatened and endangered list; species whose populations are small and widely dispersed or restricted to a few localities; and species whose numbers are declining so rapidly that official listing may be necessary.
SFD	San Felipe Division
SHP	State Historic Park
SMPP	BCDC's *Suisun Marsh Protection Plan*
SOI	sphere of influence

Term	Definition
special-status species	Any species that is listed, or proposed for listing, as threatened or endangered by the U.S. Fish and Wildlife Service or National Marine Fisheries Service under the provisions of the Endangered Species Act; any species designated by the U.S. Fish and Wildlife Service as a "listed," "candidate," "sensitive," or "species of concern"; and any species listed by the State in a category implying potential danger of extinction.
SP	State Park
SPFC	State Plan of Flood Control
SRA	State Recreation Area
Standardized Emergency Management System (SEMS)	Established throughout California to manage and coordinate any emergency response involving more than one agency or jurisdiction. It is the cornerstone of the emergency response system and the fundamental structure for the response phase of emergency management. SEMS is authorized under the California Emergency Services Act for managing multiagency and multijurisdictional responses to emergencies in California.
State	State of California
stormwater capture system	A facility operated by a public agency and designed to capture and retain stormwater flowing upon the public right-of-way, or through a public stormwater management system or a public stormwater drainage system, for subsequent use.
stressors (ecosystem)	Actions or factors, whether human or natural, that cause negative impacts on desirable ecosystem elements, processes, and functions. *See also: globally determined stressor, legacy stressors, current stressors, and anticipated future stressors.*
stressor fees	A companion principle to user fee, stressor fees are paid by persons who have been identified as stressing Delta natural systems. The fees fund regulatory and restoration programs.
subsidence	Sinking of the land surface due to a number of factors, including groundwater extraction, agricultural activities, or oil or gas extraction. In the Delta, land subsidence is mainly caused by oxidation of peat soils, but also from wind erosion. Drainage and cultivation dries the saturated peat, reducing its volume by approximately 50 percent.
subsidence reversal	The exposure of bare peat soils to air causes oxidation and decomposition, which results in subsidence, or a loss of soil elevation, on Delta islands. Flooding these lands and managing them as wetlands reduces exposure to oxygen, resulting in less decomposition of organic matter, which stabilizes land elevations. Wetland vegetation cycles lead to biomass accumulation, which sequesters carbon and helps stop and reverse subsidence. As subsidence is reversed, land elevations increase and accommodation space (the space in the Delta that lies below sea level and is filled with neither sediment nor water) on individual islands is reduced. A reduction in accommodation space decreases the potential for water quality impacts from salinity intrusion in the event of one or more levee breaks on deeply subsided Delta islands.

Term	Definition
subventions	Payments made by the State in the form of matching funds for the purpose of maintaining and improving Delta levees. The Delta Levees Maintenance Subventions Program is a cost share program providing technical and financial assistance to local levee-maintaining agencies in the Sacramento–San Joaquin Delta for the maintenance and rehabilitation of nonproject and eligible project levees. The subventions program is authorized by Water Code sections 12980 through 12995 and is managed by the California Department of Water Resources.
surface storage	Reservoirs used to collect and hold water for future release and use.
surface water	Water naturally open to the atmosphere including rivers, lakes, reservoirs, ponds, streams, impoundments, seas, and estuaries.
sustainable communities strategy	Regional transportation agencies are required to develop a sustainable communities strategy. The strategy is intended to demonstrate how the region will meet its greenhouse gas reduction target through integrated land use, housing, and transportation planning.
SWP	State Water Project
SWRCB	State Water Resources Control Board
threatened species	As defined by the California Endangered Species Act, a threatened species is a native species or subspecies of a bird, mammal, fish, amphibian, reptile, or plant that, although not presently threatened with extinction, is likely to become an endangered species in the foreseeable future in the absence of the special protection and management efforts required by the act. Any animal determined to be rare on or before January 1, 1985, is a threatened species (Fish and Game Code section 2067).
THM	trihalomethanes
tiered fee structures	Refers to a block-type fee structure where the unit price of a quantified benefit or impact, such as the amount of water used or the volume of contaminants discharged, increases with each additional block of benefit or impact.
TMDL	See total maximum daily load
total maximum daily load (TMDL)	A calculation of the maximum amount of a pollutant that a water body can receive and still safely meet water quality standards.
total water use	In the Delta Plan, refers to 60 to 65 million acre-feet of water in California that goes to urban, agricultural, and Central Valley environmental water uses such as instream flow requirements and non-CVP managed wetlands.
tributary	A river or stream that flows into a larger river or stream. Usually, a number of smaller tributaries merge to form a river.
unimpaired flow	The natural water production of a river basin, unaltered by upstream diversions, storage, or by export or import of water to or from other watersheds.
urbanization	The expansion of residential, commercial, and industrial development into rural areas or areas that may have previously been used for agricultural or ecosystem habitat.
urban water use	The use of potable and nonpotable water for urban purposes including, but not limited to, residential, commercial, industrial, recreation, energy production, military, and institutional purposes.

Term	Definition
urban water use efficiency	Water management measures that are implemented in residential, commercial, industrial, and institutional settings that reduce water and per capita water use and result in the most effective use of water to prevent its waste, unreasonable use, or unreasonable method of use.
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
user fees	Fees proposed to fund programs identified in the Delta Plan that are paid by the users or beneficiaries of those programs. Fees may be volume-based or impact-based.
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UWMP	See urban water management plan
vector-borne disease	Disease that results from an infection transmitted to humans and other animals by blood-feeding anthropods, including mosquitoes, ticks, and fleas. Examples of vector-borne diseases include Dengue fever, viral encephalitis, Lyme disease, and malaria.
waste discharge requirement (WDR)	An order adopted by a regional water board that regulates and permits specified discharges of waste to surface water and discharges of waste to land.
water balance	An analysis of the total developed/dedicated supplies, uses, and operational characteristics of water in a region. The analysis is intended to determine if actual water use equals supply.
water demand	An economic principle that describes consumer desire and willingness to pay a price for a specific amount of water. Holding all other factors constant, the price of a good or service increases as its demand increases and vice versa.
water export	The amount of water that a hydrologic region transfers to another hydrologic region. *See also: Delta exports.*
water import	The amount of water brought in from another hydrologic region or regions.
water quality criteria	Numeric limitations or levels (for example, concentrations) or narrative statements established to protect uses of a water body under the authority of the Clean Water Act. This term has two separate meanings: (1) Water quality criteria promulgated by the U.S. Environmental Protection Agency under Clean Water Act section 303(c) are enforceable components of water quality standards. (2) Recommended water quality criteria published under Clean Water Act section 304(a) are advisory and may be used by states and tribes to develop their own water quality standards or to implement narrative criteria in water quality standards.
water quality objectives	Numeric limitations or levels (concentrations or narrative statements) that are established for the reasonable protection of the beneficial uses of a water body. Determination of what is reasonable may include factors that are not required in federal development of a water quality criterion. Water quality objectives are included in water quality control plans adopted by regional water boards.

Term	Definition
water quality standards	Pursuant to the federal Clean Water Act, water quality standards are provisions of State or federal law that define the water quality goals of a water body, or portion thereof, by establishing (a) designated uses of water to be protected, and (b) water quality criteria to protect those uses. Water quality standards are enforceable in the bodies of water for which they have been promulgated.
water recycling	(1) The treatment of wastewater to remove solids and certain impurities to meet a beneficial use or a controlled use that would not otherwise occur, thus supplanting or augmenting a potable, or potentially potable, supply. (2) The treatment of municipal, industrial, or agricultural wastewater for reuse.
watershed	The land area that drains into a stream. The watershed for a major river may encompass a number of smaller watersheds.
water shortage contingency element	The Urban Water Management Planning Act requires water suppliers to include a water supply reliability and water shortage contingency element in urban water management plans, recognizing that suppliers need to prepare for extended droughts or the potential catastrophic interruption of water deliveries due to earthquakes or other events.
water supply reliability	See sidebar in Chapter 3, "What Does It Mean to Achieve the Goal of Providing a More Reliable Water Supply for California?"
water supply reliability element	Required components of urban water management plans (Water Code section 10631(c)), agricultural water management plans (Water Code section 10826 (b)(7)), and integrated regional water management plans (Water Code section 10540(c)(1)).
water transfer	A temporary or long-term change in the point of diversion, place of use, or purpose of use due to a transfer or exchange of water or water rights. Many transfers, including transfers among contractors of the State Water Project or Central Valley Project, do not fit this definition. A more general definition of a water transfer is a voluntary change in the way water is normally distributed among water users in response to water scarcity. Compared to water exchanges, which are typically water delivered by one water user to another water user, the receiving water user will return the water at a specified time or when the conditions of the agreement are met (Water Code section 1735).
water year	A compilation of hydrologic records collected over a 12-month period.
water year-type classifications	California Department of Water Resources uses five water year-type classifications for planning and water management purposes: wet, above normal, below normal, dry, and critically dry.
WDR	See waste discharge requirement
Wild and Scenic River	A State- and federal-designated river system that includes 17 California rivers and their many forks and tributaries. Approximately 1,900 miles of river are designated wild, scenic, or recreational under the National Wild and Scenic Rivers Act (1968) and the California Wild and Scenic Rivers Act of 1972.
X2	The location in the Bay-Delta where the tidally averaged salinity is 2 parts per thousand.

References

Poff, N. L., and J. V. Ward. 1989. Implications of streamflow variability and predictability for lotic community structure: a regional analysis of streamflow patterns. *Canadian Journal of Fisheries and Aquatic Sciences*. 46:1805-1818.

Richter, B. D., J. V. Baumgartner, J. Powell, and D. P. Braun. 1996. A method for assessing hydrologic alteration within ecosystems. *Conservation Biology* 10(4), 1163-1174.

Walker, B. 1995. Conserving biological diversity through ecosystem resilience. *Conservation Biology* 9(4), 747-752.

Photo Credits

Chapter divider *(clockwise from top left)***:** Chris Austin, California Department of Water Resources, Dave Feliz

Exhibit C

to Comments on the Department of Water Resources Draft Environmental Impact Report for the Water Supply Contract Extension Project

SAN FRANCISCO BAY:

THE FRESHWATER-STARVED ESTUARY

HOW WATER FLOWING TO THE OCEAN SUSTAINS CALIFORNIA'S GREATEST AQUATIC ECOSYSTEM

The Bay Institute

SAN FRANCISCO BAY:

THE FRESHWATER-STARVED ESTUARY

HOW WATER FLOWING TO THE OCEAN SUSTAINS CALIFORNIA'S

GREATEST AQUATIC ECOSYSTEM

PREPARED FOR: San Francisco Estuary Partnership

BY: The Bay Institute

SEPTEMBER 2016

The Bay Institute

bay.org

The Bay Institute is the research, policy and advocacy arm of bay.org, a nonprofit organization dedicated to protecting, restoring and inspiring conservation of San Francisco Bay and its watershed, from the Sierra to the sea. Since 1981, the Bay Institute's scientists and policy experts have worked to secure stronger protections for endangered species, water quality, and estuarine habitats; reform how California manages its water resources; and design and promote comprehensive ecological restoration projects and programs in San Francisco Bay, the Sacramento-San Joaquin Delta, the Central Valley watershed, and the Gulf of the Farallones.

San Francisco Bay: The Freshwater-Starved Estuary was commissioned by the San Francisco Estuary Partnership, which provided the majority of the funding for the project. Additional support was provided by Ben Hammett; Robert and Anne Layzer; Robin and Peter Frazier; Corinne and Mike Doyle; Morgan and Bill Tarr; Steven and Susan Machtinger; and the Bay Institute Aquarium Foundation.

The report was researched and written by staff of the Bay Institute's Rivers and Delta Program: Alison Weber-Stover (Staff Scientist), Greg Reis (Staff Scientist), and Jonathan Rosenfield, Ph.D. (Conservation Biologist and Lead Scientist), with assistance from Peter Vorster (Hydrogeographer), under the direction of Gary Bobker (Program Director), who also co-authored and edited the report. Report design and production was overseen by Ashley Spiker (http://www.thespikerexperience.com).

THE BAY INSTITUTE

Pier 35, The Embarcadero at Beach Street

mailing address: Pier 39, Box #200

San Francisco, CA 94133

www.thebayinstitute.org

info@bay.org

TABLE OF CONTENTS

SAN FRANCISCO BAY:

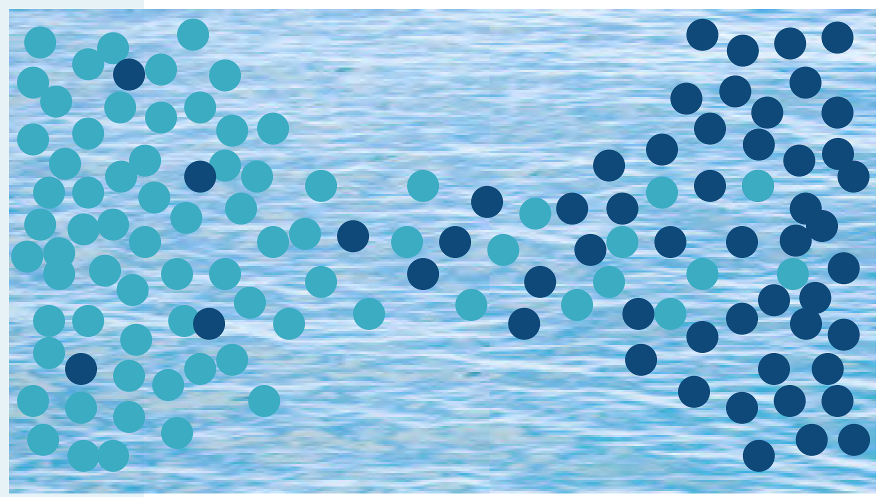
THE FRESHWATER-STARVED ESTUARY

The Bay Institute

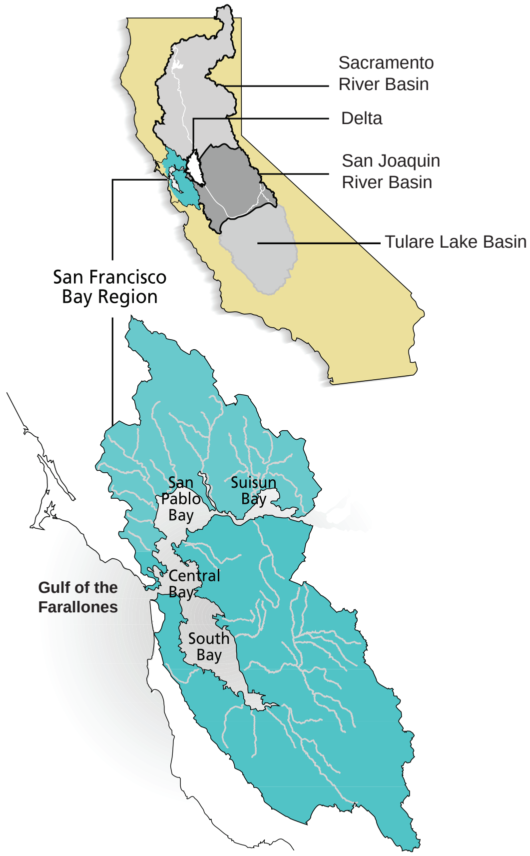
EXECUTIVE SUMMARY

INTRODUCTION

THE INFLOW OF FRESH WATER DRIVES THE HEALTH OF THE SAN FRANCISCO BAY ESTUARY AND ITS WATERSHED, FROM MOUNTAIN RIVERS TO THE PACIFIC OCEAN OUTSIDE THE GOLDEN GATE



San Francisco Bay is an estuary, where salt water and fresh water mix to form a rich and unique ecosystem that benefits fish, wildlife and people. Fresh water sustains the Bay ecosystem. Drastic changes to Bay inflow place the ecosystem, and the services it provides to all of us, at risk.



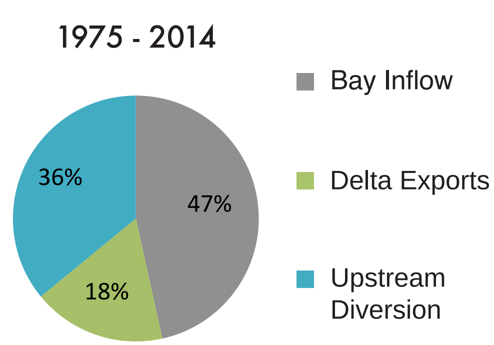
WHERE HAS ALL THE FRESH WATER GONE?

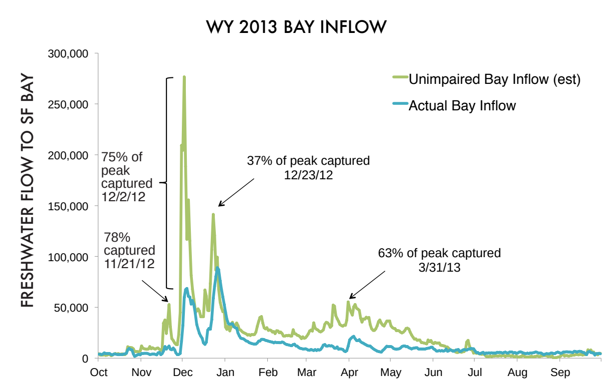
FRESH WATER NATURALLY FLOWED TO THE BAY – UNTIL WE STARTED CAPTURING AND REDIRECTING MOST OF IT, ESPECIALLY DURING ECOLOGICALLY CRITICAL PERIODS

Historically, most Bay *inflow* came from winter rains and spring snowmelt, which kept the upper estuary fresh most of the year and created increasingly brackish and saline habitats moving downstream to the Golden Gate. The Bay's fish and wildlife *evolved to take advantage* of these patterns of flow and habitat.

But, after building thousands of dams, over 600 large reservoirs, and 1,300 miles of diversion canals throughout the Bay's watershed, the flow that now reaches San Francisco Bay is **on average less than 50%, and in some years less than 35%**, of what it would be without those impairments. Ecologically critical winter and spring flows have been cut even more, with **about a third** of the seasonal unimpaired runoff and, just **one-fourth** of the runoff from some storms reaching the Bay.

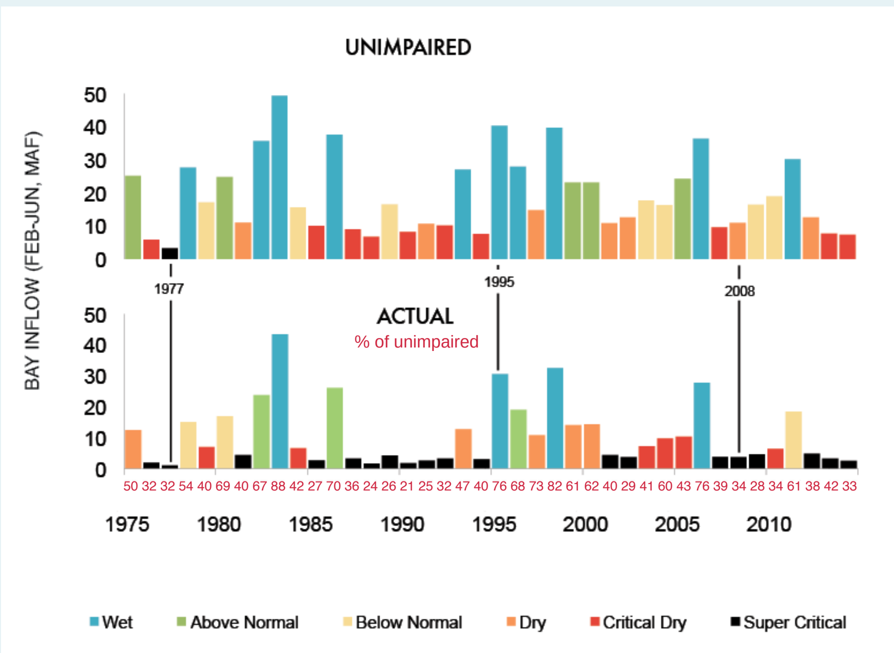
California's *water wars* – the fight over how much water cities, agriculture and the environment will get – are fought *upstream*, in the Bay's watershed and in areas that take water out of it. But *downstream*, in the Bay estuary and nearby coastal waters, is where the *outcomes of radically altering and reducing flows* can be seen most clearly. These outcomes include fish and wildlife species at serious risk of extinction, degraded water quality, shrinking beaches and marshes, and so much more.





THE CHANGE IS SO EXTREME THAT THE SAN FRANCISCO BAY ECOSYSTEM NOW EXPERIENCES A DEVASTATING, PERMANENT DROUGHT

Between 1975 and 2014, the unimpaired runoff in the watershed was only low enough to create a “supercritically dry’” year **once**, in 1977. But upstream diversions captured so much runoff during those four decades that the Bay experienced “supercritically dry” conditions – the amount of inflow typical in extreme drought – in **19 years** instead of only one. The resulting collapse of the Bay’s ecosystem is no surprise.



STARVING THE BAY

EXTREME FLOW REDUCTIONS DAMAGE THE BAY’S ECOSYSTEM

How much fresh water makes it to the estuary, *when*, and for *how long*, shapes the Bay’s ecosystem. Reducing Bay inflows so dramatically shifts the size and location of the ecologically important *salinity mixing zone*, reduces the inflow of *nutrients, food*, and *sediment* from the watershed that are vital components of fish and wildlife habitat; allows *pollutants* to accumulate; and facilitates *invasions* by undesirable non-native species.

SALINITY

The transition from fresh water to the ocean forms a gradient of increasingly saline habitats that are critically important for the estuary’s fish and wildlife. The amount and timing of inflow determines *where* and *how extensive* these productive low salinity habitats are. Winter and spring inflows move the critically important low salinity zone downstream in the upper reaches of San Francisco Bay. The *abundance* and *distribution* of many estuarine fish and invertebrate populations are *strongly* and *persistently associated* with the location of this zone; when it moves downstream, native species numbers increase.

Periods when the **average salinity was as high as in the past half-century previously occurred only three times in the last 1,600 years** – during recent droughts, January – July salinity was the highest it has been in 400 years. Reducing Bay inflow this drastically forces the low salinity zone to **move upstream**, exposing larval and juvenile fish to **poor water quality and habitat conditions** in the Delta, facilitating the **spread of**

invasive non-native species, and driving population **declines** of native species. Shifting the salinity field upstream also **brings salty water to fresh and brackish water marshes,** reducing the productivity of wetland habitats and number of plant and animal species in them, and slowing the formation of new soil.

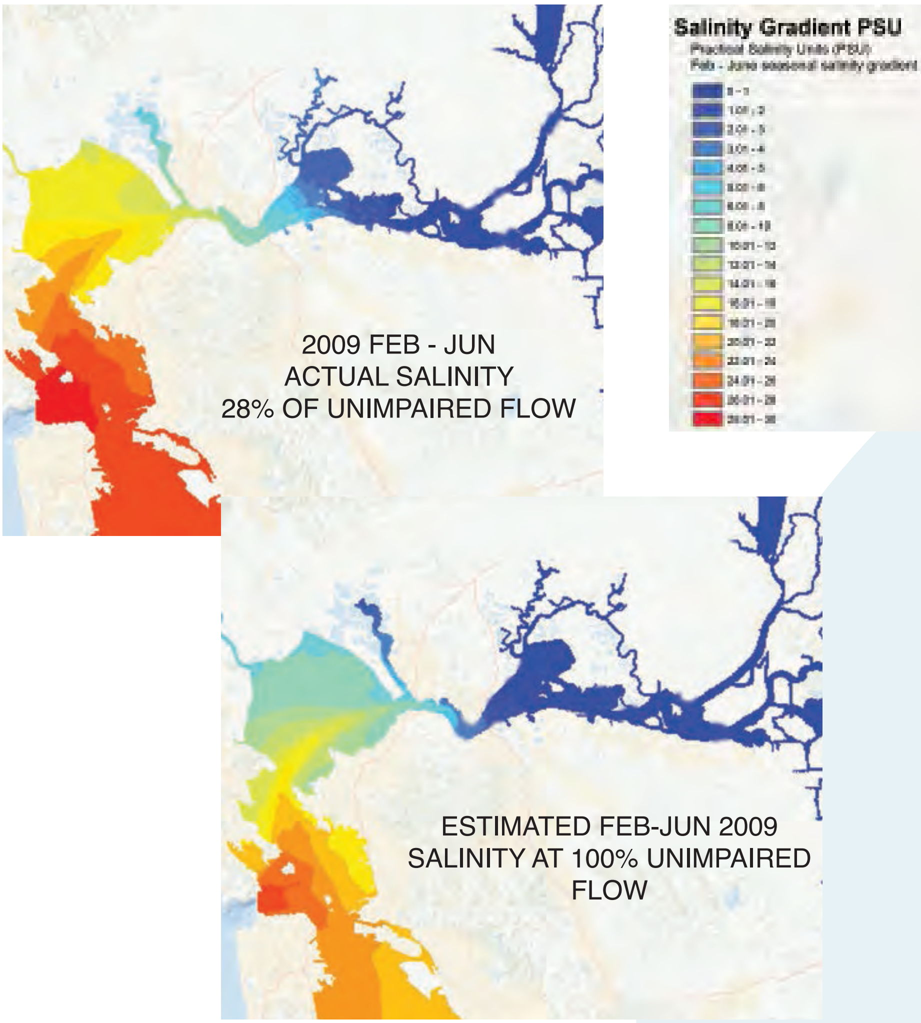
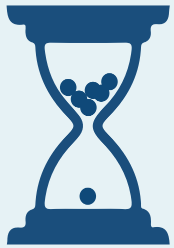


Photo Credit: David Sanger

Further downstream, **persistent increased salinities** from reduced inflow displace the native invertebrate community in the Central Bay, **allowing non-native sea squirts to dominate** the subtidal zone. In the South Bay, freshwater inflows riding on the surface over a deeper, saltier layer support *the base of the food web* with *large plankton blooms;* the effect is dampened when flows are reduced. Similarly, outside the Golden Gate, a *plume of brackish water* that forms when winter and spring flows to the Bay ride on the surface, *stimulates plankton growth* and facilitates the movement of *nutrient-rich bottom water* into the Bay. Because so much fresh water is captured upstream, salinity at the estuary's downstream boundary has increased and the brackish water plume has diminished. In combination with warming seas, reduced flows from the Bay to nearshore waters are likely to **lower productivity** and increase the risk of **starvation and reproductive failure** in seabirds, fish, and marine mammals.

SEDIMENT

Higher Bay inflows carry more sediment (gravel, silt, and other particles), which helps *form and maintain wetlands and beaches*, and make the estuary's waters *more turbid*, or cloudy, protecting fish and invertebrates from predators. But dams and diversions capture sediment and reduce sediment-carrying flows. Sand makes up 70% of the Sacramento River's sediment load when flows are high; reducing flows helped **cut the sediment load in half** between 1957 and 2001. Flow reduction combined with other factors facilitated the shrinking of sandy beaches in the Bay by **two-thirds**, a **50%** increase in coastal erosion, and a decline of up to **40%** in turbidity in the upper estuary.

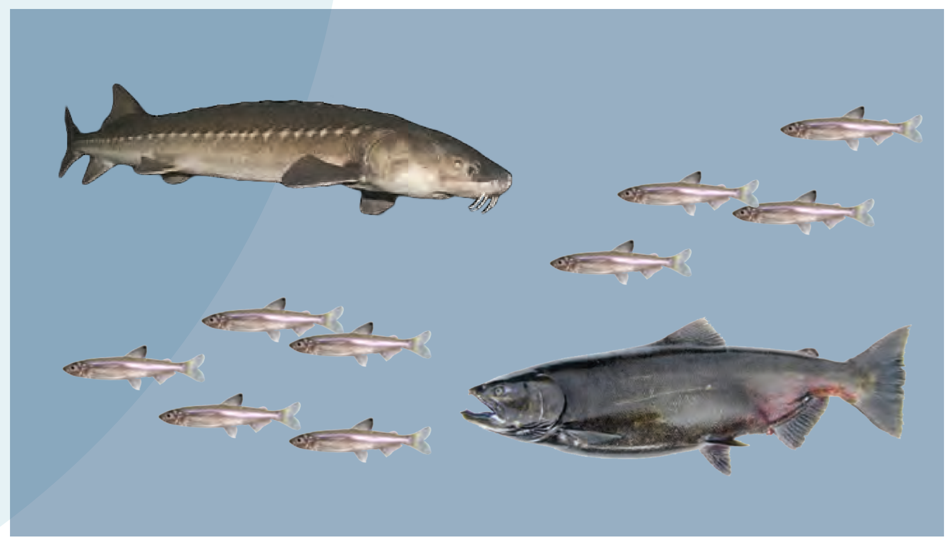


POLLUTION

When Bay inflows are low, concentrations of chemical and biological contaminants build up, sometimes to toxic levels, and increase the amount of time these pollutants spend in the estuary. Heavy metals and synthetic compounds like **copper, mercury, PCBs** and **silver** are more readily incorporated by aquatic organisms, at lower flows. The trace element **selenium**, which causes **birth defects** and **reproductive mortality** in many species, accumulates more rapidly in clams, and the fish and birds that prey on them, when flows are at the low levels seen in recent years. Low flows also encourage **toxic algae blooms,** which produce **neurotoxins** that build up in the environment and can kill animals and sicken people. These blooms are becoming **more frequent** in the upper estuary, and their toxins are detectable throughout the Bay.

FOOD WEB PRODUCTIVITY

San Francisco Bay is a *highly productive nursery* for fish, birds, mammals, and invertebrates like crabs and shrimp. Freshwater inflow stimulates the Bay estuary's food web by *increasing production of fish and large planktonic animals* that thrive in the muddy waters and wetlands that are created and sustained by sediment-laden peak flows. Flows also *transport* some of these organisms to other parts of the estuary, where they become prey for other species. **Altering flows alters the food web.** As flows decline, the **biomass of important invertebrate prey populations like Bay shrimp declines** correspondingly; water clarity increases, increasing the **rate of predation** on food prey species; and **non-native species colonize the estuary**, competing with or preying on native species. If the amount and timing of Bay inflows are allowed to more closely approximate natural patterns, these effects can be reversed.



WHO SUFFERS FROM THE BAY'S FRESH WATER STARVATION DIET?

The Bay ecosystem supports more than *750 plant and animal species*, including four unique runs of *Chinook salmon*, and millions of *waterbirds*. Seven million residents and more than twice as many visitors enjoy *seafood* produced locally in this estuary, *recreate* along its shores or in its waters, and draw satisfaction from its *wetlands* and *wildlife*. Reducing Bay inflows puts all of these values at risk.

VIABLE FISH AND WILDLIFE POPULATIONS NEED FRESH WATER

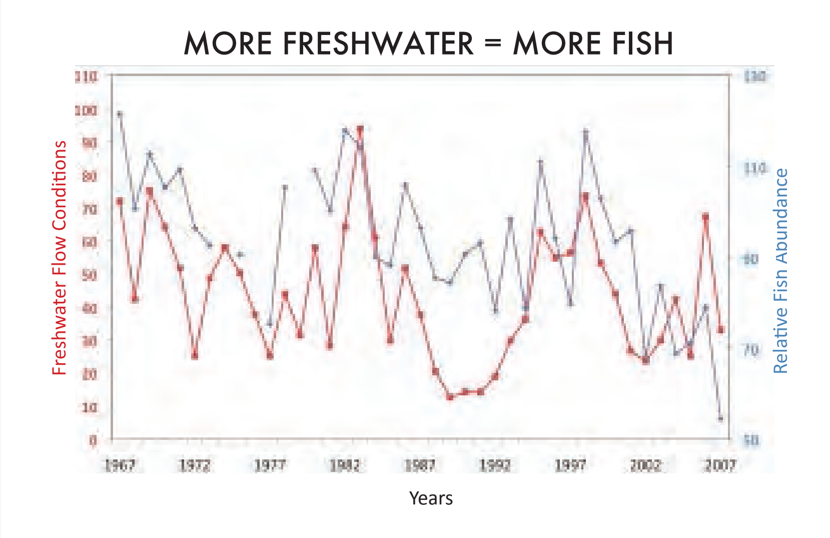
Conditions in the flow-starved estuary are very different from those in which native plants and animals evolved. As a result, some of the **most common species**, like Delta smelt, Chinook salmon, and sturgeon, are now among the **rarest**. What these and many other species – organisms that vary in their life histories, role in the food web, and location in the estuary – have in common is the *strong relationship between flow and healthy populations*.

To be viable, the Bay's plants and animal populations need to be:

- abundant (higher populations ensure long-term survival through a range of different conditions)
- diverse (increased variation among individuals increases the odds that some will respond successfully to changing environmental stresses)
- productive (faster population growth rates allow species to exploit good conditions in a variable environment); and
- spatially distributed (exists in a large enough area reduces the risks posed by local catastrophes)

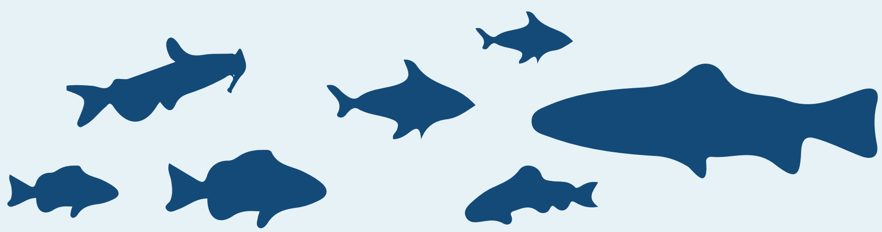
ABUNDANCE

Reproduction, growth, and migration of many species, from invertebrates to forage fish to migrating salmon, are timed to occur during the critical winter and spring months when flows are higher. The *number of individuals* in these populations is strongly influenced by *how much Bay inflow* occurs during this period – this is one of the best-documented facts known about the Bay estuary. The dramatic decline in abundance of many populations closely tracks the dramatic decline in winter – spring Bay inflows; that is, **less flow has resulted in less fish** – for some species, populations are at **record or near record low levels.** In contrast, the abundance of many non-native species is inversely proportional to flow, increasing under low flow conditions. Flows in the fall also create brackish water habitat for Delta smelt and help returning adult salmon find their home spawning grounds.



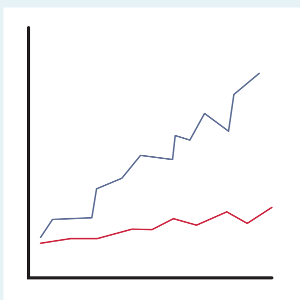
DIVERSITY

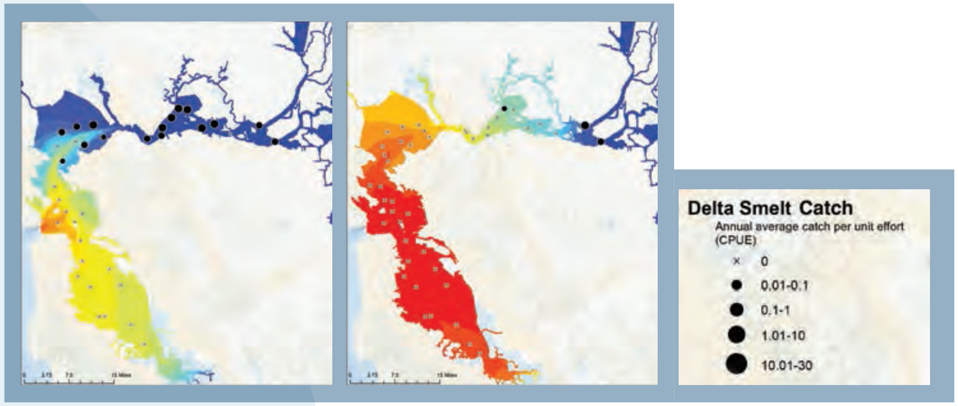
A population with more diverse individuals is *less vulnerable to extinction* because it has a *portfolio* of possible behavioral and ecological responses to changing or variable conditions. Restricting the amount and timing of flows year after year favors the survival of a **small subset of individuals** that are only able to prosper under a limited set of conditions. For instance, nearly **eliminating peak Bay inflows from the San Joaquin River and replacing them with small artificial pulses that occur during just one month** narrows the migration window for Chinook salmon, in essence gambling that these fish will reach the ocean exactly when food supplies and other conditions are good. The **collapse of California's salmon fisheries** shows that this gamble has not paid off.



PRODUCTIVITY

Fish and wildlife populations that can *grow quickly* can *rebound quickly* following times when conditions are poor. The Bay estuary's species evolved to rebound in wetter years after periods of drought. But the Bay's "permanent drought" means that wet years are infrequent and much less wet, and drier years are extremely dry and nearly continuous. As a result, the **higher flows that would allow populations to rebound rarely occur**, and the growth rate is limited or even negative.





SPATIAL DISTRIBUTION

When all individuals in a population are concentrated in a small area, the population is **more vulnerable to extinction** due to localized catastrophes. Lower Bay inflows significantly **reduce the size of the low salinity habitat** that many species depend on. Low inflows also shift this habitat– and the populations using it – upstream, exposing imperiled fish to the giant Delta pumps, where on average **9 million fish** are screened out of the exported water each year - **most do not survive** from the experience. In addition, to creating important habitat types, freshwater inflows to the Bay also help transport organisms between essential habitats. By **degrading water quality, eliminating signals that fish and wildlife use to orient themselves**, and **even drying up sections of rivers**, low Bay inflows can prevent populations from spreading out or migrating.

Photo Credit: Richard Eskite

DRIVING RECREATIONAL AND COMMERCIAL FISHERIES TO THE EDGE?

The flow and habitat conditions that once prevailed in San Francisco Bay made the area a *hub of commercial and recreational fishing activity on the West Coast*, with important fisheries for salmon, sturgeon, smelt, striped bass, and other species. The long-term trend of reducing Bay inflows has been a major factor in the **loss of thousands of fishing jobs** over the past few decades and the **historic closure of the ocean salmon fishery** in 2008-2010. While deteriorating ocean conditions, upstream habitat degradation, and poor hatchery management also played a role, scientists studying the closure have identified **better flow conditions as one of the few actions that can be taken to restore** the salmon fishery. **Starry flounder, sturgeon, and splittail** are other commercially valuable fisheries that depend on adequate flows and that are **also at risk.**

FLOW (AND FORAGE FISH) IS FOR THE BIRDS...

Forage fish (small fish and large invertebrates) that are *food items* for many larger fish, bird and mammal species perform a *crucial function* in the estuary's food web. For instance, fish-eating birds, such as pelicans, terns, and cormorants, rely on the existence of sufficient forage fish populations to feed them. Populations of many once common native forage fish species, like smelt, salmon, and shrimp, have **declined dramatically** in response to extreme reductions in Bay inflows and are now well below the levels needed to maintain viable populations of **other fish, pelagic seabirds and marine mammals,** so these other populations **are at risk of collapsing** too. Also, as reduced inflows reduce the area of brackish and freshwater wetlands or convert them to salt marsh, their **habitat value** for many bird populations is likely to **diminish.**

...AND THE WHALES

Marine mammals like seals and whales are a great tourist attraction in the Bay Area and the Northern California coast. By diminishing productivity and constricting the estuary's food web, reduced Bay inflows produce cascading effects that eventually create problems for these species. For example, **Orca whales** outside the Golden Gate prey on Chinook salmon, which were historically abundant and high in fat content; **dwindling salmon runs threaten** the local whale population.

… AND THE PEOPLE

Bay Area residents and tourists don't just benefit from Bay inflows by catching fish, buying local seafood, or going whale watching. They also *wade, swim, sail and kayak* its waters and play on its *beaches* and in its *wetlands*. But low flows **degrade water quality** in general and are now beginning to cause periodic **harmful algae blooms,** in particular. Some cyanobacteria blooms produce **neurotoxins powerful enough to make humans sick** and kill small mammals; although the blooms occur in the upper estuary, neurotoxins produced upstream have been detected in the Central Bay. Low Bay inflows also **threaten the continued existence** of beaches and wetlands throughout the region. As rising sea levels and other forces erode these popular areas, water diversions **limit the peak flows** that would normally resupply them with sediment.

Photo Credit: David Ferris

A Bay Area where it's hard to catch salmon, see pelicans or Orca whales, find today's local catch at the restaurant, hang out at the beach, or even be in contact with the water? This is a **high price to pay for ignoring the effect** of the radical alteration of Bay inflows on the many ecosystem services and economic benefits that the San Francisco Bay estuary provides.

TURNING THE FLOW BACK ON

Fortunately, there are actions that Californians can take to avoid that increasingly likely scenario.

ADOPT STRONGER WATER QUALITY STANDARDS FOR THE BAY ESTUARY NOW

Overwhelming evidence demonstrates that today's **21-year old Bay-Delta water quality standards do not require nearly enough flow** to protect the beneficial uses of the San Francisco Bay Estuary's waters as mandated by the Clean Water Act. That finding has been confirmed time and again by policy makers, regulatory agencies, and independent science review panels. Yet California is still years away from completing the update of its standards begun in 2009, despite the federal requirement to review standards every three years. It's **time to end the delays and adopt new standards** that require enough flow to restore estuarine productivity and viable fish and wildlife populations, discourage the establishment and spread of invasive non-native species, and use indicators of biological and ecosystem health to measure progress and increase effectiveness.

REQUIRE ALL WATER DIVERTERS TO CONTRIBUTE THEIR FAIR SHARE

The primary responsibility for meeting Bay estuary water quality standards falls on a small subset of water districts that get water from the federal and state water projects. These agencies represent **a quarter or less of total water use** in the Bay's watershed. Requiring all water users, including those with senior water rights, to contribute a **fair share** would spread the burden more equitably and generate **millions of acre-feet of additional water to restore the estuary.** It's also time to more broadly overhaul California's antiquated water rights system, which favors older water claims over the needs and public benefits generated by different water uses; this system has also awarded the right to use **five times more water in California than occurs naturally**, on average.

REDUCE RELIANCE ON THE DELTA AS A SOURCE OF WATER SUPPLY

In 2009, California adopted a landmark policy to reduce reliance on water supplies from the Delta region of the upper estuary and increase local self-reliance in areas that take water out of the Delta. California has only begun to tap the potential for local self-reliance; using water more efficiently, reusing and recycling water, cleaning up degraded water, capturing and reusing stormwater runoff, and storing water underground in aquifers **could save up to 14 million acre-feet of water** – over half the total amount of water used for human use throughout the Bay's watershed each year – each year. Implementing the new policy could also significantly **reduce California's carbon footprint;** for instance, transporting water via the State Water Project represents about 3% of the state's total energy consumption. Setting **targets for conserving water in the agricultural sector** – which uses about 80% of the state's developed water supplies – would generate additional water to restore a healthy Bay estuary and establish greater parity between agriculture and the urban sector, which is required to achieve a per-person conservation target of 20% by 2020.

Photo Credit: Fernand Ivaldi Getty Images

INTEGRATE FLOW AND HABITAT RESTORATION TO BATTLE CLIMATE CHANGE

Wetlands and beaches not only provide important habitat for fish and wildlife; they also act as natural flood barriers to protect shoreline communities in the Bay Area and Northern California. Loss of sediment supply and rising sea levels threaten to erode these benefits by literally eroding wetlands and beaches to nothing. **Freshwater flow regimes that help maintain wetlands and beaches** should be a part of efforts to design, evaluate, and permit restoration of these critical areas.

WE MUST ACT NOW

The science overwhelmingly indicates that more freshwater flow, following a more natural pattern, must reach the San Francisco Bay estuary to restore its fish, wildlife, water quality, food web, marshes, beaches, coastal fisheries, and other public benefits. The only barriers to action are the general lack of understanding about the severely degraded condition of this freshwater flow-starved estuary and the lack of political will to change the unsustainable way California manages its water resources. Can Californians be made aware of the pending collapse of the Bay estuary ecosystem – and the loss of all that ecosystem provides us – and motivated to demand action now? Can decision-makers at every level – federal, state, and local – be prevailed upon to take the steps necessary to prevent the destruction of California's greatest aquatic ecosystems before it is too late? The window of opportunity to protect this treasure is closing rapidly.

Butter Lupine Photo Credit: David Sanger

INTRODUCTION

THE FLOW OF FRESH WATER DRIVES THE HEALTH OF THE BAY AND ITS WATERSHED, FROM MOUNTAIN RIVERS TO THE PACIFIC OCEAN OUTSIDE THE GOLDEN GATE

The San Francisco Bay estuary is one of the world's great ecosystems – a natural treasure comparable in scale and importance to the Everglades, Chesapeake Bay or the Great Lakes. Like these other large ecosystems, the health of San Francisco Bay is at risk from many environmental insults. Contaminated agricultural runoff and legacy pollutants poison aquatic food webs. Invasive plants and animals compete with native species for food and habitat. Only a small fraction of its original wetlands remain. But perhaps the most serious and seemingly intractable threat comes from the large-scale and unsustainable diversion of the fresh water that should flow to the Bay from its vast watershed in California's Central Valley ("Bay inflow"). The radical alteration of Bay inflow is intimately connected to every other problem that threatens the Bay estuary's ecosystems. The inescapable facts are that the Bay estuary is being starved of the freshwater flow that makes it California's greatest aquatic ecosystem – and that people don't understand that fresh water flowing to the ocean is what keeps the Bay alive.

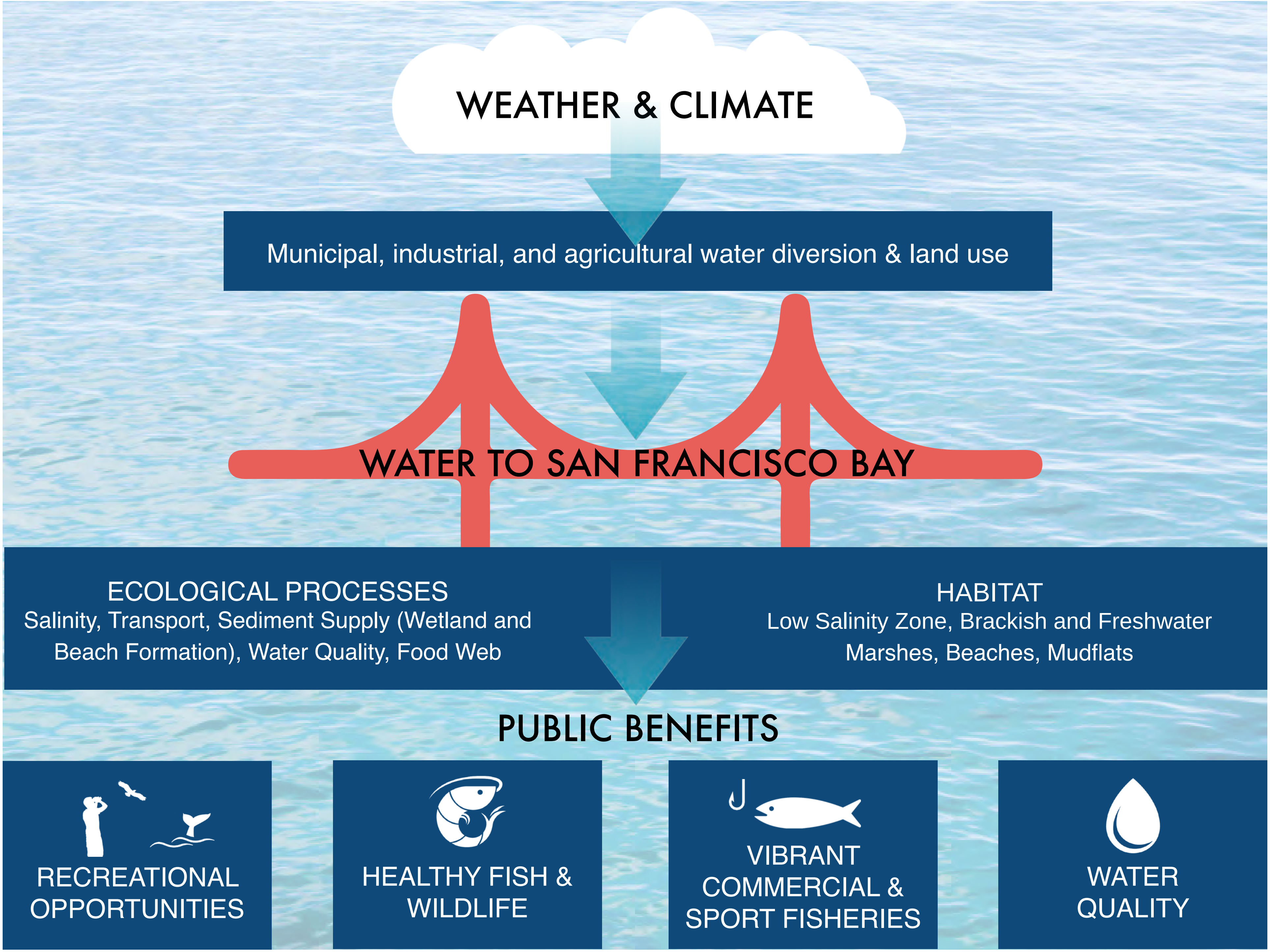
Freshwater flows define the San Francisco Bay estuary. As the place where fresh water and saltwater mix, the estuary provides a unique brackish water ecosystem for hundreds of plant and animal species – many found nowhere else on Earth. San Francisco Bay is the most famous and recognizable part of this estuary, an ecosystem formed by the mixture of fresh water from the rivers and streams of California's Central Valley and salt water from the ocean. When freshwater inflow to an estuary is drastically altered, as in it has been for San Francisco Bay, the very nature of the ecosystem is changed, with dramatic consequences for the fish and wildlife that depend on the estuary's unique habitats. Ultimately, people who enjoy the many benefits this ecosystem offers – from its fishable and swimmable waters to its beaches and rich wetland habitats – lose out when we deny the estuary the freshwater flow it needs.

THE BAY IS A MAJOR BUT UNAPPRECIATED CASUALTY IN CALIFORNIA'S "WATER WARS"

The long-standing conflicts over how much water should be diverted from the estuary and its watershed to provide water for irrigation, industry, and drinking water supplies are often depicted as occurring far upstream from San Francisco Bay. News stories describe battles over how much water should be held back in the thousands of reservoirs in the Bay's watershed, or diverted from Central Valley rivers, or exported by the giant pumps in the Sacramento-San Joaquin Delta, in order to be delivered to cities and farms. Government agencies and water districts fight over appropriate limits on water extractions in order to safeguard water quality, fish, and wildlife. People debate whether agribusiness should grow thirsty crops that depend on government subsidies and water from overdrafted groundwater basins and distant watersheds, and whether agricultural water use should be metered in our semi-arid environment.

What is rarely mentioned is that the outcomes of all battles in these water wars affect the Bay and the coastal ocean outside the Golden Gate. Most of the freshwater flow that shaped these environments historically is captured today in a massive system of reservoirs, siphons and pumps. The loss of freshwater flow is harming the Bay and the nearshore marine ecosystems, the fish and wildlife that depend on them, and the humans that benefit from and enjoy them (Figure 1).

Figure 1: The amount and timing of critical freshwater inputs to the estuary are a function of what nature provides and the amount of water humans divert and store upstream. Unsustainable water diversions lead to altered ecological processes and degraded habitats which produce cascading effects on many beneficial uses that people gain from a functioning estuary ecosystem. The amount of fresh water reaching San Francisco Bay generates myriad public benefits, including healthy fish and wildlife populations, improved water quality, viable commercial and recreational fisheries, and ample recreational opportunities such as enjoying beaches or viewing wildlife.


WEATHER & CLIMATE
Municipal, industrial, and agricultural water diversion & land use
WATER TO SAN FRANCISCO BAY
ECOLOGICAL PROCESSES
Salinity, Transport, Sediment Supply (Wetland and Beach Formation), Water Quality, Food Web
HABITAT
Low Salinity Zone, Brackish and Freshwater Marshes, Beaches, Mudflats
PUBLIC BENEFITS
RECREATIONAL OPPORTUNITIES
HEALTHY FISH & WILDLIFE
VIBRANT COMMERCIAL & SPORT FISHERIES
WATER QUALITY

CALIFORNIA'S PAST INVESTMENTS IN THE BAY ARE AT RISK

Californians have invested a half-century of effort and billions of dollars to control water pollution, restore wetlands and prevent exotic species from being introduced to the Bay estuary. But that enormous financial and social investment is at risk unless we let a larger share of the watershed's runoff flow downhill to the Bay. Californians can protect their investment in the Bay by changing the water use and water management practices that prevent us from protecting the freshwater flows that support this majestic ecosystem and the jobs that rely on its health.

This report describes how:

• The Bay's natural freshwater flow regime has been altered by the world's largest system for capturing and moving water;

• The estuary's vital ecological processes, including salinity distribution, transport of sediments, nutrients, and food, pollution control, habitat availability, and food web dynamics, are damaged by these alterations to the natural runoff pattern; and,

• The living beings that depend on the health of the Bay, from simple aquatic plants, to forage fish, to migrating salmon, to marine mammals, to humans, are at serious risk from the loss of services the Bay ecosystem provides.

WHERE HAS ALL THE FRESH WATER GONE?

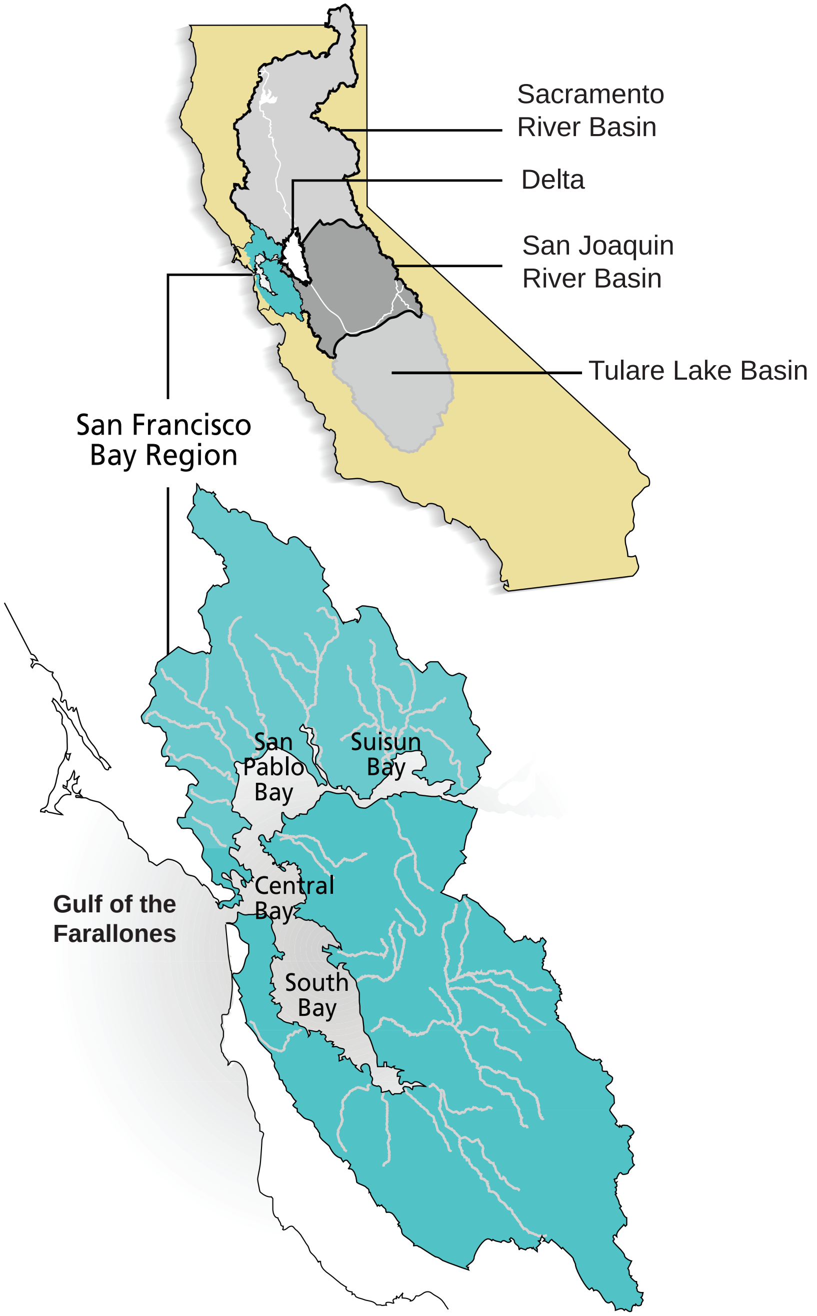
PATTERNS OF NATURAL AND ALTERED FLOW TO SAN FRANCISCO BAY

San Francisco Bay is part of the largest estuary on the west coast of the Americas. The estuary extends from the inland Delta where the Sacramento and San Joaquin Rivers of California's Central Valley converge, out to the nearshore coastal waters of the Gulf of the Farallones. The Bay itself encompasses four major embayments – Suisun Bay, San Pablo Bay, Central Bay, and the South Bay (Figure 2).

THE SAN FRANCISCO BAY ESTUARY AND ITS WATERSHED

Figure 2: From the peaks of the mountain ranges surrounding the Central Valley to the Golden Gate, the San Francisco Bay watershed historically drained up to 40% of California's land area. Most of the Bay's inflow comes from rivers and streams that flow into the Sacramento and San Joaquin Rivers and then is funneled through the Delta to the Bay. Locally important creeks and rivers that discharge directly into the Bay contribute about 10% of the Bay's freshwater inflow. The once vast Tulare Lake periodically overflowed into the San Joaquin River, but now the basin of this dry lakebed contributes water to the Bay only in the wettest years.

Sacramento - San Joaquin Delta
Photo Credit: David Sanger



Freshwater flow drives everything that happens here. The Bay's vast watershed now drains about a third of the land area of California, collecting surface and ground water from the Sacramento and San Joaquin River watersheds, and in exceptionally wet years, from the Tulare Lake Basin, south of Fresno (which contributed water to the Bay more frequently before the construction of the current water supply system). Smaller rivers and creeks that flow directly into the Bay such as the Napa River, Guadalupe River, Sonoma Creek, Coyote Creek, Alameda Creek, San Francisquito Creek and Walnut Creek contribute less than 10% of inflow[1].

FRESH WATER NATURALLY FLOWED TO THE BAY....

The natural pattern of freshwater inflow to the Bay is shaped by California's Mediterranean climate. About 80% of the annual precipitation in the Bay's watershed occurs from November through March[2]. Winter storms can deposit large amounts of rain or snow in a matter of days, increasing runoff dramatically for short periods and periodically freshening the Bay. As temperatures warm in the spring, accumulated water held in the mountain snowpack – the state's largest "reservoir" – melts and flows into the Bay, with high runoff that freshens the Bay for a much longer period than the peak flows that follow winter rainstorms. The high volume of the spring flow establishes an ecologically important salinity gradient in the estuary, which creates freshwater habitats in the Delta and parts of northern San Francisco Bay and increasingly brackish water habitats closer to the Golden Gate. As freshwater flows to the Bay decline in late summer and early fall, the zone of brackish water moves upstream as far as the western part of the Delta. Except under drought conditions, the Delta remains a freshwater ecosystem throughout the year[3].

As discussed later in this report, the estuary's native species have adapted to this naturally variable pattern of inflow to the Bay. The first pulses of runoff from winter storms trigger the migratory journeys of juvenile salmon and cue fish that live in the Delta and northern San Francisco Bay to begin to move to spawning areas. The large winter floods and spring snowmelt shape habitat availability in the estuary and drive numerous essential ecological processes downstream.

High year-to year variability in precipitation and runoff is characteristic of a Mediterranean climate. Multi-year wet periods and dry periods (droughts) also are typical. Since the mid-1970s, the Bay's watershed has experienced three very dry periods (1976-1977, 1987-1992, and 2012-2015) and two extended wet periods (1978-1986; 1995-2000). Within the last millennium, the watershed has experienced even longer (decade- to century-long) droughts and wet periods[4]. The high variability between seasons and across years and the resulting shifts in the estuary's salinity were probably essential in limiting the establishment of invasive non-native species prior to the 20th century.

... UNTIL WE DISRUPTED THE PATTERN – AND RADICALLY REDUCED FLOWS TO THE BAY

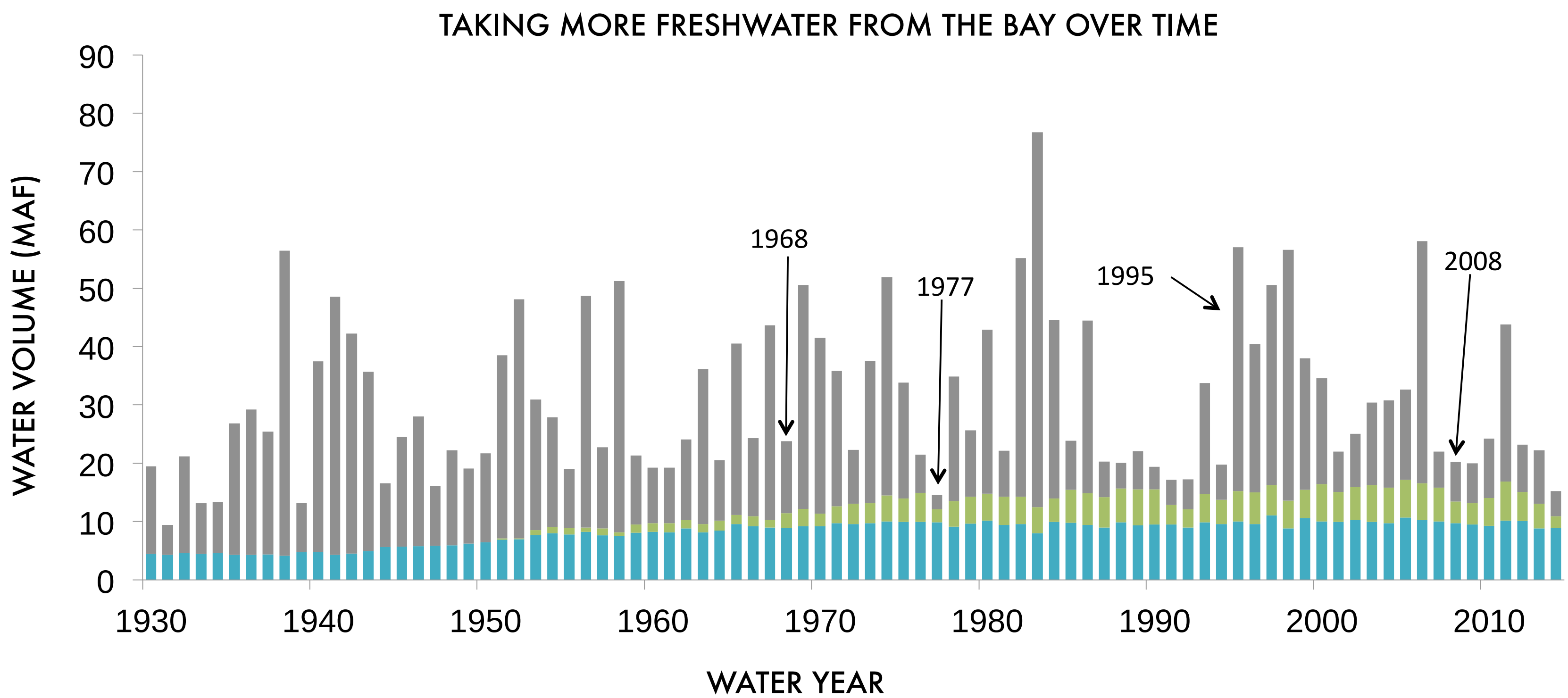
By draining and filling wetlands and floodplains for conversion to agriculture and denuding hillsides for mining and logging, Californians began to change the pattern of runoff from the Bay's watershed in the latter half of the 19th century. These actions reduced the watershed's capacity to absorb snowmelt and storm runoff and increased the sediment load in rivers and streams. Agricultural diversions upstream of the estuary also increasingly reduced the total amount of fresh water that made it to the estuary. The impact on Bay inflows throughout the watershed became more pronounced in the 1920s and 1930s as flood control projects were built in the Sacramento Valley, the construction of dams and use of motorized pumps for wells drove the tremendous expansion of irrigated agriculture, and growing Bay Area cities started importing water from rivers that drained to the Bay. Urban landscapes, with their impermeable surfaces, further decreased the watershed's ability to retain or slow runoff from periodic storms. Much larger inflow changes resulted from the construction and operation of the massive federal Central Valley Project (CVP) – including Shasta Dam on the Sacramento River, Friant Dam on the San Joaquin River, and the Tracy Pumping Plant in the Delta – in the 1940s and 1950s.

The final component in the radical alteration of the Bay's hydrology came in the 1960s and 1970s when the State Water Project (SWP) began operating the Banks Pumping Plant in the Delta that exports water to cities in the southern Bay Area and Southern California and agriculture in the San Joaquin Valley. Together, the state and federal Delta pumping facilities are part of the world's largest water storage and conveyance system; they have become the single largest extractor of the Bay watershed's fresh water. Since 1985 the combined CVP/SWP exports from the Delta have averaged over 5 million acre-feet per year, and over 6 million acre-feet per year in the period from 2000 to 2007 (Figure 3).

Since the SWP began exporting water from the Delta, a variety of state, federal, and local water agencies have constructed many more large dams and canals throughout the Sierra Nevada and Central Valley to capture, store and transport watershed runoff. Thousands of dams, over 600 large reservoirs, and 1300 miles of aqueducts now store and re-distribute over 30 million acre-feet of water, roughly equivalent to the surface water runoff from the entire watershed in an average year[5].

This massive transformation of the watershed has dramatically altered every component of the natural Bay inflow pattern, including the magnitude and timing of flows, the frequency and duration of high flow events, and the variability between high and low flows. The magnitude of the reduction in freshwater flow inputs is revealed by comparing the amount of water that actually reaches the Bay to the amount that would have reached the Bay if there were no dams, diversions, or exports of water ("unimpaired flow" or "unimpaired runoff"). The percentage of annual unimpaired flow that actually reached the Bay prior to the completion of Shasta Dam (1945) was much greater than it has been since the SWP began withdrawing major amounts of flow from the Bay's watershed, in 1968. Since 1975, total annual flow is on average less than 50% of what it would be without storage in dams, diversions, and direct exports from the Delta (Figure 3). In some years, it is less than 35% (Figure 5, left panel). Worse yet, even greater reductions in flow during the ecologically important winter and spring seasons occur frequently.

TAKING MORE FRESHWATER FROM THE BAY OVER TIME



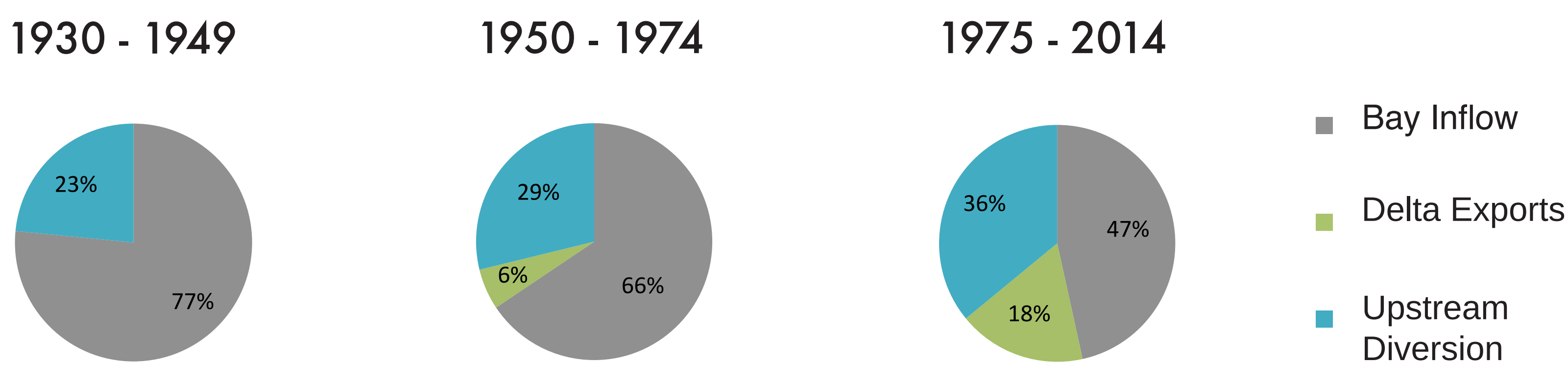


Figure 3: The amount of fresh water that would flow to San Francisco Bay from California's Central Valley (bars, top panel) varies tremendously from one year to the next. By contrast, the amount of available Central Valley runoff that is diverted or stored upstream (aqua bars) or exported from the estuary (green bars) for agricultural, industrial and municipal uses has increased steadily over the last half century. As a result, the proportion of water diverted or exported from the estuary has also dramatically increased over the same time period (pie charts, bottom panel), leaving less water to flow into the Bay (grey). Recently, diversions and exports of water have averaged approximately half of the amount available – in dry years, much less than half the runoff reaches the Bay. Important years identified in the figure, include 1968, when the State Water Project began exporting water from the Delta; 1977, a record drought year; 1995, when water quality standards for the estuary were last updated; and 2008, when new federal protections for imperiled Delta smelt, Chinook salmon, steelhead, and green sturgeon were issued.

About 80% of the water diverted from the Bay's watershed is used for agricultural irrigation. Photo credit: Fernand Ivaldi, Getty Images

SAN FRANCISCO BAY'S DEVASTATING, PERMANENT DROUGHT

Because Bay inflows have been drastically reduced and flow patterns radically altered, the estuary has experienced extreme drought conditions for much of the past four decades. The amount of runoff associated with the very driest years was once the exception. It is now the new normal. The overall change in Bay inflows from human water use has been so severe that the Bay ecosystem is experiencing a nearly permanent drought (Figure 4). The driest winter – spring period in the last 95 years occurred in 1977. But because so much runoff is now captured (especially during the winter and spring months), the estuary experienced 1977-like, "super-critically dry" conditions in 19 years, or almost half the years between 1975 and 2014. In contrast, wet year conditions (in which native species have the best chance to recover from persistently low Bay inflows) occurred in the Bay's watershed in 25% of the past 40 years. But actual flows to the Bay resembled those of wet years in just four years during the 1975-2014 period. During six of the past 10 years less than 40% of the unimpaired runoff available in the winter and spring made it to the estuary.

UNIMPAIRED

WINTER-SPRING RUNOFF CONDITIONS IN THE BAY'S CENTRAL VALLEY WATERSHED 1975-2014

ACTUAL

WINTER-SPRING INFLOW CONDITIONS IN THE BAY 1975-2014

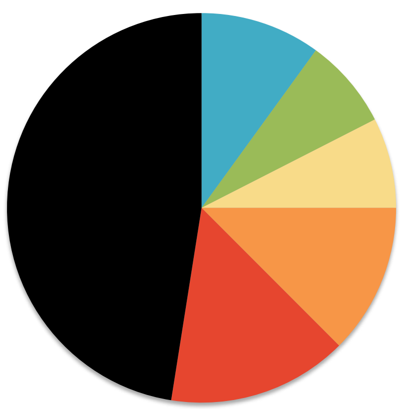
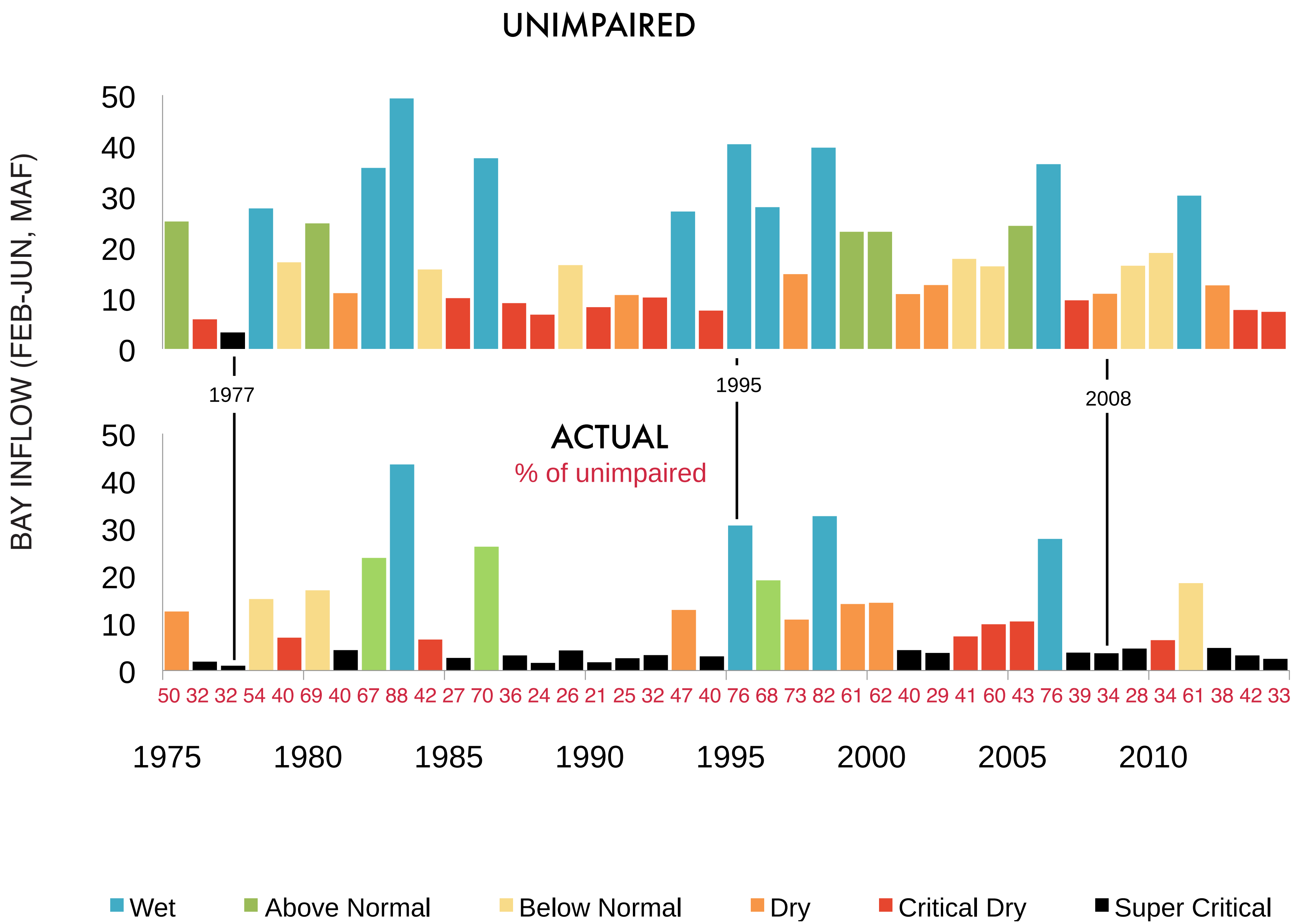


Figure 4: The Bay's vast watershed receives massive volumes of snow and rain in some years and very little in other years. Most of this water becomes runoff during the winter and spring months and many native species have evolved to capitalize on this pulse of water. The percentage of available runoff that reaches the Bay decreases as the combined total of watershed diversions and Delta exports increase. By dividing winter-spring runoff conditions into categories, the bar charts to the right show when Wet (blue), Normal (green), Below Normal (yellow), Dry (orange), Critically Dry (red), and Super Critically Dry (black) years occurred in the Bay's watershed (upper bar graph; "unimpaired") and the corresponding conditions that actually occurred in the Bay (lower bar graph, "actual"). Each of these categories represent one-fifth of the years as measured by their unimpaired runoff, except for the Super Critically Dry category, which represents the driest single year (~2.5%) of the 40 years represented here.

The pie charts show the relative frequency of these different hydrological conditions as they occurred in the Bay's watershed (upper pie chart, "unimpaired") and what the Bay's ecosystem actually experienced (lower pie chart, "actual"). As a result of intensive water diversion and exports, the estuary and its unique and valuable fish and wildlife species have experienced extremely dry conditions throughout most of the past four decades. For example, Super Critically Dry conditions, which occurred naturally only in 1977, are by far the most common conditions experienced in the estuary these days. Wet conditions occurred in the Bay less than half as frequently as they did in the watershed that feeds it. Years 1995 and 2008, marked on the bar graphs, correspond to state and federal actions that reserved relatively minor amounts of water for fish, and have failed to modify or mitigate the trend of intensive and growing diversion of Bay inflows.

BAY'S WATERSHED ACTUALLY REACHES THE BAY?



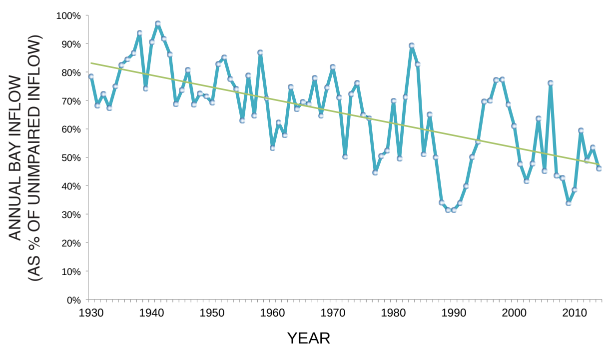
DRYING UP ECOLOGICALLY CRITICAL PERIODS

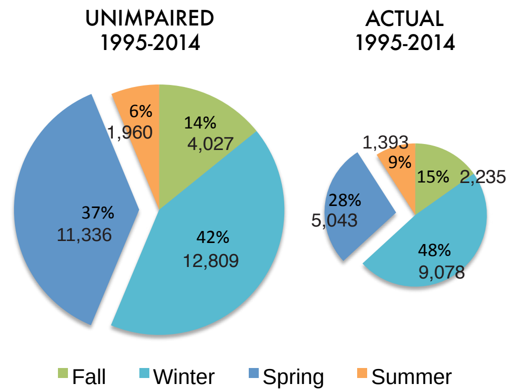
The change in total annual flow to the estuary is only one indicator of the massive changes in inflow to the Bay as a result of how California uses its limited water supply. The natural seasonal timing of flow has been modified as well (Figure 5, middle panel). For example, although over three quarters of the Bay's unimpaired inflow arrives as winter storms and spring snowmelt, the percentage of available runoff that actually made it to the Bay between February and June reached as low of 28% in 2009. During the last decade, only an average of 35% of unimpaired runoff made it to the Bay during May, making this the most impaired month of the year. In contrast, state water quality regulators report that 75% of unimpaired Bay inflow during the winter-spring period is necessary to fully protect the estuary ecosystem[6]; and in fact, scientific studies from around the world indicate that ecosystem function is severely impaired if less than 80% of freshwater flows remain in rivers[7]. When instead just one-third or less of these ecologically vital flows are allowed to make it to the Bay, there is absolutely no reason to expect any other outcome except ecological collapse.

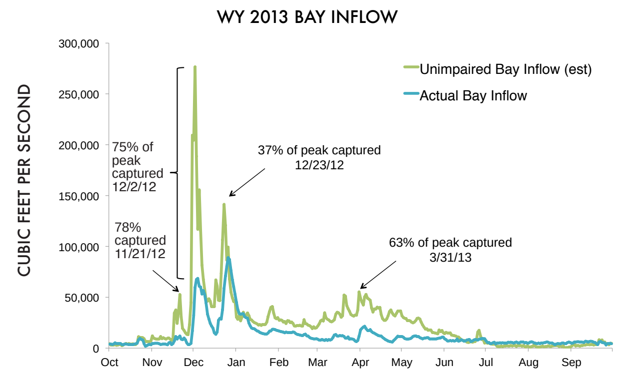
Even seasonal and monthly averages don't reveal the full impact of the change to Bay inflows – short-duration peak flows have been severely reduced, and nearly eliminated in many cases (Figure 5, right panel). In all but the wettest years, the brief pulses of flow that follow rainstorms and snowmelt events – and which are so important to migrating fish like salmon – have been virtually eliminated, as reservoirs, river diversions, and exports from the Delta capture these critical flow spikes. The biggest winter floods have been severely curtailed[8]. For example, in late November and December of 2013, 75-78% of the peak flows were captured in reservoirs, diverted upstream, or exported directly from the Delta. The precious runoff that does still make it to the Bay—from below dams and the few remaining undammed watersheds—could be further curtailed if one or more new and expanded dam and diversion projects, most of which would be very expensive, produce low yields, and be partly subsidized by taxpayer funding, are built and operated.

Upstream dams and diversions capture the majority of runoff in the Bay's watershed. Photo Credit: California Department of Water Resources

A BAY CHANGED: ALTERATIONS TO FRESHWATER FLOW







ANNUAL

Compared to the amount of runoff in the Bay's Central Valley watershed each year, the amount of water that actually reaches the Bay has been declining steadily over time. A greater proportion of available runoff (the "percentage of unimpaired flow") reaches the estuary in wetter years; during dry years the Bay receives proportionately less of the water available. This occurs because the total amount of water that humans divert and store in reservoirs does not vary much in response to annual hydrology.

Data source: CDEC and DWR Dayflow

SEASONAL

The fraction of water that would arrive in the estuary during different seasons without storage and diversions (unimpaired conditions; left pie chart) and what actually arrives after the effect of human water management (right chart, numbers are volume in thousands of acre feet). Not only is the volume of freshwater flow reduced, but the distribution of this flow across seasons is altered as well. For example, under unimpaired conditions, 37% of the Central Valley's runoff would flow to the estuary during the spring, but only 28% of the (much smaller) volume that actually makes it downstream arrives during the spring. This disproportionate reduction in fresh water flowing into the estuary during the spring occurs during the very season when native fish and wildlife population are most responsive to freshwater flow.

PEAK FLOWS

Estimated flow to San Francisco Bay during a year in the absence of storage or diversions (green line) compared with the estimated flow that actually reached the estuary (blue line). The difference between unimpaired and actual inflow on key dates shows that natural early season peaks in flow are largely eliminated by storage and diversion operations. Native species rely on pulses of water (which result from periodic rainfall and snowmelt events) to orient during migration and to cue important life cycle transitions. California's water management practices eliminate this important natural signal. The loss of short duration peak flows puts native species at a disadvantage and facilitates invasion by non-native species.

Figure 5: Water storage, diversion, and export changes the natural pattern of freshwater flow in multiple ways. The total amount of water diverted from the estuary and its watershed for human use increased steadily over time, resulting in less and less fresh water making it downstream annually (left panel). The timing of the freshwater flow that remains is also radically altered by human water management practices. For example, the seasonal timing of flow has been changed such that proportionately less water arrives during the ecologically critical spring months (center panel). Also, diversions have a disproportionate effect on short-term peak flows, which native species rely on to orient their migrations or to spawn (right panel).


American avocet Photo Credit: Judy Irving

STARVING THE BAY

HOW FLOW REDUCTIONS DAMAGE KEY COMPONENTS OF THE BAY'S ECOSYSTEM

As rivers approach the sea, salty and fresh water mix to form an estuary. In addition to diluting what would otherwise be seawater, the freshwater flowing into an estuary creates unique and productive ecosystems. Estuaries contain special fresh water and brackish (low salinity) habitats that shift position dynamically in response to the tides and seasonal or annual variations in fresh water flow. The balance between fresh and salt water determines the size and shape of these estuarine environments and their capacity to support the fish and wildlife species that have evolved to specialize in them.

How much freshwater flow makes it as far as the estuary, when it arrives during the year, and the extent to which the amount and timing of arriving flow change from year to year, all determine what kind of benefits fish, wildlife, and humans receive from the estuarine environment. When the flow of fresh water is reduced dramatically for a prolonged period of time, the transport of nutrients, food (from simple photosynthetic organisms to fish), and sediment from the watershed into the estuarine environment is reduced as well. In the absence of periodic flushing, pollutants accumulate in the system. In addition, reduced freshwater flow facilitates invasion by undesirable, non-native species and proliferation of harmful organisms that generate toxic water pollution. Alone and in combination, the effects of reduced freshwater flow into the Bay estuary undermine its water quality, its ability to support fish and wildlife populations, and the formation and maintenance of surrounding beach and wetland habitats.

This chapter describes how changing freshwater inflows to the Bay directly affects many fundamental ecological processes, including salinity distribution, transport of sediment and biological materials, pollution control, habitat formation and maintenance, and food web dynamics. In many cases the specific mechanisms through which freshwater flow into the Bay acts on these processes and habitats are understood incompletely. Flow acts as a master variable, and its interactions with different ecosystem elements are complex and difficult, if not impossible, to untangle. Yet the size and diversity of freshwater flow's effects on the Bay's ecosystem are clear. The next chapter will explain how all these flow-related changes to the Bay impact the fish, wildlife, and people who rely on it for many critical services.

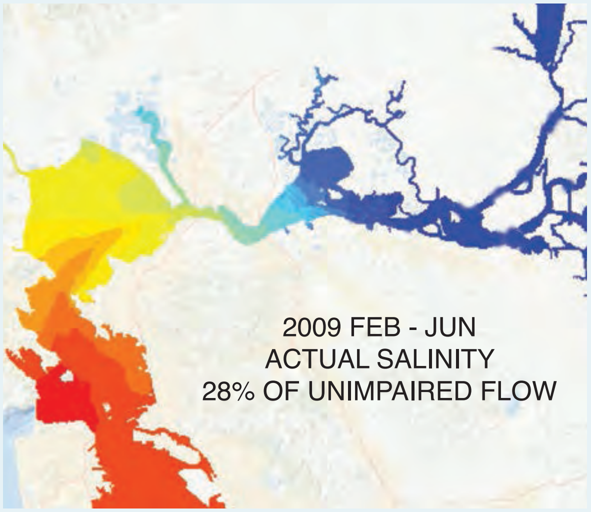
SALINITY

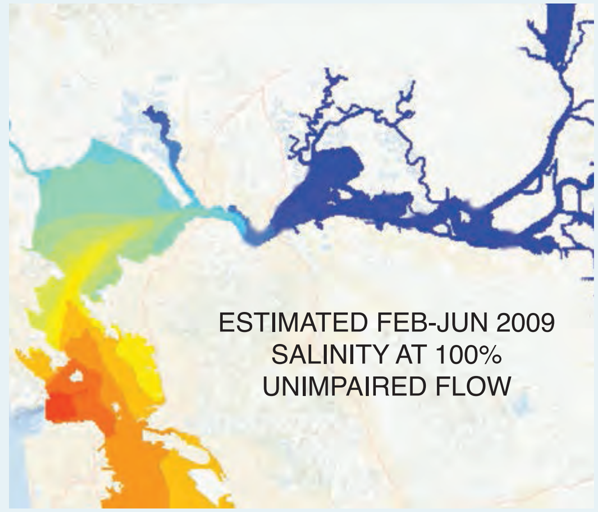
The transition from fresh water to salt water in the estuary is a dynamic gradient that moves daily, seasonally and annually. Where this transition occurs is influenced in large part by how much fresh water flows into the estuary. The amount of water at different salinity levels determines the quantity and quality of habitat for plants and animals that live in the estuary. Habitat condition and location can be altered by salinity in many ways, including:

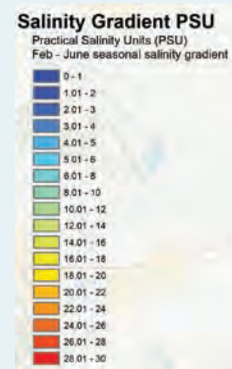
- Extent – how much habitat is there?
- Distribution – where in the estuary is the habitat available?
- Quality – how suitable is the habitat for the species that use it?
- Connectivity – can species access and move among habitats?
- Timing – is the habitat available during key life stages for species?
- Persistence – is the habitat available for multiple generations?

Reductions in freshwater flow to the Bay shift the timing and location and restrict the extent of the salinity gradient, altering estuarine habitats in ways that can translate to population level effects on species that utilize those habitats. Periods when the average salinity was as high as in the past half-century previously occurred only three times in the last 1,600 years – during recent droughts, January – July salinity was the highest it has been in 400 years. The timing of peak inflow has been changed from May to February, changing the position of the estuary's salinity field throughout the spring and summer months[9] (Figure 6). How the salinity field is affected depends on what part of the estuary is being considered.

THE EFFECT OF WATER DIVERSION ON SALINITY IN THE BAY







In 2009, a Dry year in the Bay's watershed, only 28% of available runoff from the Central Valley made it to the Bay; the rest was diverted, stored, or exported. Because there was so little fresh water, Central Bay, San Pablo Bay, and even parts of Suisun Bay became very salty.

Had no water been stored, diverted, or exported, the salinity distribution in 2009 would have looked more like this (the actual salinity distribution in 1980). Fish and wildlife that use freshwater and brackish habitats would have been able to use all of Suisun Bay and most of San Pablo Bay.

Figure 6: Water diversions and exports affect the distribution of salinity throughout the Bay. Most aquatic organisms are sensitive to the salinity of their habitat; thus, changes in salinity distribution reflect changes in habitat availability for many of the Bay's species. These maps show the actual distribution of salinity in one Dry year (2009; left panel) and what the salinity distribution would have looked like without diversion or export of fresh water (right panel).

Data sources: U.S. Environmental Protection Agency. Salinity Gradient - Coarse-grid version of UnTRIM San Francisco Bay-Delta Model, Delta Modeling Associates.
Basemap - ESRI, DeLorme, BEBCO, NAANGDC, & other contributors

GROUND ZERO: THE SALINITY TRANSFORMATION OF NORTHERN SAN FRANCISCO BAY AND THE DELTA

Bay fish and their prey benefit from lower salinities at critical times: A unique and ecologically critical area known as the low salinity zone (LSZ) occurs in the upper, northern part of the estuary. This zone is especially important for juvenile fish and invertebrates[10]. Historically, as freshwater flows naturally increased in the winter and spring, the LSZ was located in the broad, shallow reaches of Suisun and San Pablo Bays, and shifted gradually upstream in the summer and fall. Numerous scientific studies over many decades have documented the powerful and persistent correlations between the abundance of many of the Bay's fish populations, including longfin smelt, starry flounder, and striped bass, with the position of the LSZ in the ecologically sensitive winter and spring period[11]. That is, the number of fish of many estuarine populations increases as the LSZ moves downstream in response to increasing flows. How fish and invertebrate populations are distributed is also correlated with the location of the LSZ, with benefits decreasing as the zone shifts upstream with less inflow. For example, the position of the LSZ during the winter and spring affects the exposure of larval and juvenile fish to diversion into the large export pumps in the southern Delta[12]. The abundance and distribution of Delta smelt are also correlated with the location of the LSZ in the fall[13].

Several types of zooplankton (small invertebrate animals) are also strongly affected by the position of the LSZ, including mysid shrimp, Bay shrimp, and seasonal populations of other small zooplankton[14]. These organisms are essential food for the Bay's fish and wildlife populations. The historic zooplankton community in the LSZ has been devastated over the past three decades by a combination of reduced freshwater inflows to the Bay, increased water exports from the Delta, and the introduction of non-native invasive species[15]. Allowing more of the Central Valley's natural flow of fresh water to reach the estuary during the spring is one of the few tools available to improve the distribution and increase the abundance of important zooplankton species in the open waters of San Francisco Bay.

Exotic species invade when salinities are less variable: Reducing inflows not only constrains the downstream movement of the LSZ but also generally keeps the salinity field more uniform and less dynamic from season to season and year to year in the upper reaches of the estuary. This reduced salinity variation is a primary factor in the establishment and success of undesirable non-native plant and animal species. For example, establishment of nuisance species such as the overbite clam appears to have reduced phytoplankton abundance in the upper estuary[16]. There is evidence that exotic zooplankton invasions are facilitated by consistently low inflow to San Francisco Bay[17]. Some introduced species, like inland silverside – a voracious predator – increase in abundance during periods when flows are low[18]. Once established, these invaders contribute to deteriorating habitat conditions for native species by competing for food, space and other important habitat needs.

Wetlands change as salinity changes: The freshwater and tidal marshes and riparian areas that occur on the margins of the upper estuary buffer the land from tides and storm surges and support over 500 fish and wildlife species, including a large number of rare species such as Suisun song sparrow, San Francisco common yellowthroat, California black rail, and giant garter snake[19]. Restoring wetland habitat is a high priority for current management efforts; currently, less than one tenth of historic wetland remains around the Bay and only 4% in the Delta[20].

Pollen records indicate that extended periods with higher than average salinity have previously occurred only three times in the last 1,600 years[21]. Since 1950, primarily as a result of flow reductions and flow pattern alterations throughout the Bay's watershed, we are now experiencing the fourth such period[22]. Tidal marshes with higher salinity have lower numbers of plant species and are less productive[23]. Even short-term changes in freshwater inflows can convert freshwater marsh to brackish marsh, and brackish marsh to salt marsh; as temperatures, atmospheric CO2, and salinities all rise, the longer-term impact of wetland conversion could have large consequences on ecosystem function[24].

Ridgway's Rail (formerly, Clapper Rail) is one of many species native to the San Francisco Bay area that are endangered. These secretive birds, which rarely fly, forage in tidal mudflats and make their homes in the upper vegetated zone of the marshes that once dominated the Bay's margin. Photo Credit: David Sanger

Small shifts in salinities can affect how seeds germinate, grow, and are distributed; which species occur; and how much food the marsh provides for fish and wildlife[25]. For instance, during the short but severe 1976-77 drought, a marsh at the east end of the Carquinez Strait became much more saline and plant composition shifted, with bulrush decreasing and salt-tolerant pickleweed invading. These changes can be long lasting; according to one study, when salts accumulate in tidal marsh soils, "larger pulses of fresh water of greater duration will be required to reduce soil salinities in the marsh and promote germination and recruitment"[26].

Marsh formation is critical as a tool for adapting to climate change. Salinity plays a key role in the rate at which marshes can rise in response to changing sea levels. Organic matter accumulates faster in freshwater marshes, and the rate of soil formation decreases with increasing salinity[27]. Absent sufficient freshwater inflow, sea level rise will push the salinity field further inland, reducing the area available for brackish and freshwater habitats in the upper reaches of the estuary. The resulting conversion of brackish and freshwater wetlands to salt marsh will reduce the amount of marsh area that can buffer the impact of rising seas. As marshes erode, so too do the benefits of flood regulation and water quality control that they provide to communities along the estuary's shores. Also, reductions in the area of less saline marsh habitat will affect species like black rails that depend on vegetation not found in salt marshes.

LOOKING DOWNSTREAM: SALINITY CHANGES IN CENTRAL AND SOUTH SAN FRANCISCO BAY ARE ALSO A PROBLEM

Farther downstream, the saltier Central and South Bays also experience major salinity changes when freshwater runoff into the Bay is high. In the winter and spring— the time of year when human activity alters flows the most – reducing Bay inflow can change salinity distribution in the Central and South Bay even more than in the upper estuary[28]. During the 1987-1992 drought, for example, when inland water diversions and exports reached (then) record high levels, the winter – spring salinity at Fort Point, under the Golden Gate Bridge, was the highest experienced in 400 years[29].

Species in Central Bay shift in response to flow-related salinity changes: What kinds of species are present in the Bay near San Francisco, and how they interact, are influenced by freshwater inflow and the salinity field. For instance, rates of growth, reproduction and migration for invertebrates in the Bay like oysters, barnacles, and sea squirts (sessile marine invertebrates) are highly affected by freshwater inflows. When winter inflows are reduced, large non-native sea squirt species dominate the invertebrate community, competing for space and limiting populations of other species, such as oysters. Although prolonged exposure to fresh water during very high flood flows may kill oysters, new oyster populations readily establish at lower salinities, probably in response to the limiting effects of higher flows on their invasive competitors[30].

Seasonal salinity stratification dominates the South Bay: During the summer and fall, the lagoon-like South Bay is about as salty as the ocean, with circulation driven by the tides and winds. But, in winter, high freshwater inflow from the upper estuary can cause strong density-driven currents to form, with fresher water on top and saltier water on the bottom—a phenomenon known as stratification. As Bay inflow diminishes through the spring, and as more saline water outside the Golden Gate is drawn into the Bay by tides, the Central Bay becomes saltier and a density-driven current of more saline water flows into the South Bay along the bottom. The South Bay is usually stratified in the spring, and unstratified in summer and fall. This seasonal pattern causes a spring peak in phytoplankton productivity[31], and many fish species respond positively to the changes in South Bay salinity associated with the variation in Bay inflow[32].

BEYOND THE BAY: FLOW EFFECTS ARE FELT IN THE GULF OF THE FARALLONES

Salinity changes in the saltiest part of the estuary – the Gulf of the Farallones, just west of the Golden Gate – are also most influenced by the seasonality and magnitude of freshwater flows. During winter and spring, outflows from the Bay create a plume of brackish water (as low as 20 parts per thousand [ppt] salinity and up to 5 meters deep), stimulating phytoplankton growth and contributing to overall foodweb productivity in the Gulf of the Farallones, a protected marine sanctuary[33]. At times, this plume briefly extends as far offshore as the Farallon Islands and Cordell Bank. The plume tends to turn to the north in winter, extending as far as Ft. Bragg, CA. During the summer when flows are lower, the plume is smaller but still extends outside the Golden Gate, turning to the south[34].

Plankton and larger organisms such as salmon, sharks, and marine mammals all converge at the plume front. Birds that nest on the Farallon Islands also feed at the plume front. But this highly productive, flow-driven habitat is being diminished. Bay inflow accounts for 86% of the variability in salinity at the Golden Gate[35]. Salinity at the ocean boundary has increased by 12 parts per million per year since 1920[36], showing that the brackish water plume has become substantially reduced over time[37].

Sevengill shark Credit: Aquarium of the Bay

The Bay – ocean connection is a two way street: Increased inflow to the Bay and subsequent outflow to the ocean during the spring increases the exchange of water, nutrients, and organisms in both directions. Wind-driven coastal upwelling brings denser, cooler, nutrient-rich, saltwater closer to the ocean surface. As this marine water flows into the Bay, it benefits bottom-feeding organisms[38]. When spring inflows to and outflows from the Bay are reduced, not only are the ecological benefits of the brackish water plume at the surface affected, but the importation of saltier water along the bottom is also cut back, reducing nutrient inputs to the Bay's benthic habitats[39].

These two phenomena – upwelling of nutrient-rich water and the brackish plume – interact to form the rich marine ecosystem of the Gulf of the Farallones. Reducing inflows to the Bay not only limits the benefits the Bay receives from both of these ecologically important processes, but may also affect the productivity of coastal environments. Indeed, the state of our scientific understanding indicates that freshwater flows into the estuary have multiple effects that reach far downstream into marine environments. According to a recent study:

> "The effects of [freshwater flow from the watershed] propagated further down the estuary salinity gradient than [effects from the Pacific Ocean] that propagated up the estuary salinity gradient, exemplifying the role of variable freshwater outflow as an important driver of biotic communities in river-dominated estuaries."[40]

In plain English, freshwater flow impacts downstream areas more than the more saline habitats downstream impact the fresher upstream areas. As the effects of climate change become more acute, the benefits of freshwater flow for coastal waters will become even more critical. Warming ocean conditions, weaker upwelling, and shifts in the Pacific Decadal and North Pacific Gyre Oscillation are reducing marine productivity along the California coast with cascading effects on the food web[41]. As productivity declines, birds, fish and marine mammals are more likely to starve and less likely to reproduce successfully. For these creatures, improving freshwater flows would help grow the food items, such as juvenile salmon, that are an important part of the offshore food web, and would also restore seasonal brackish surface water habitats in the Gulf of the Farallones, supplying fuel for the marine ecosystem outside the Golden Gate and potentially helping to offset oceanic climate change effects.

SEDIMENT

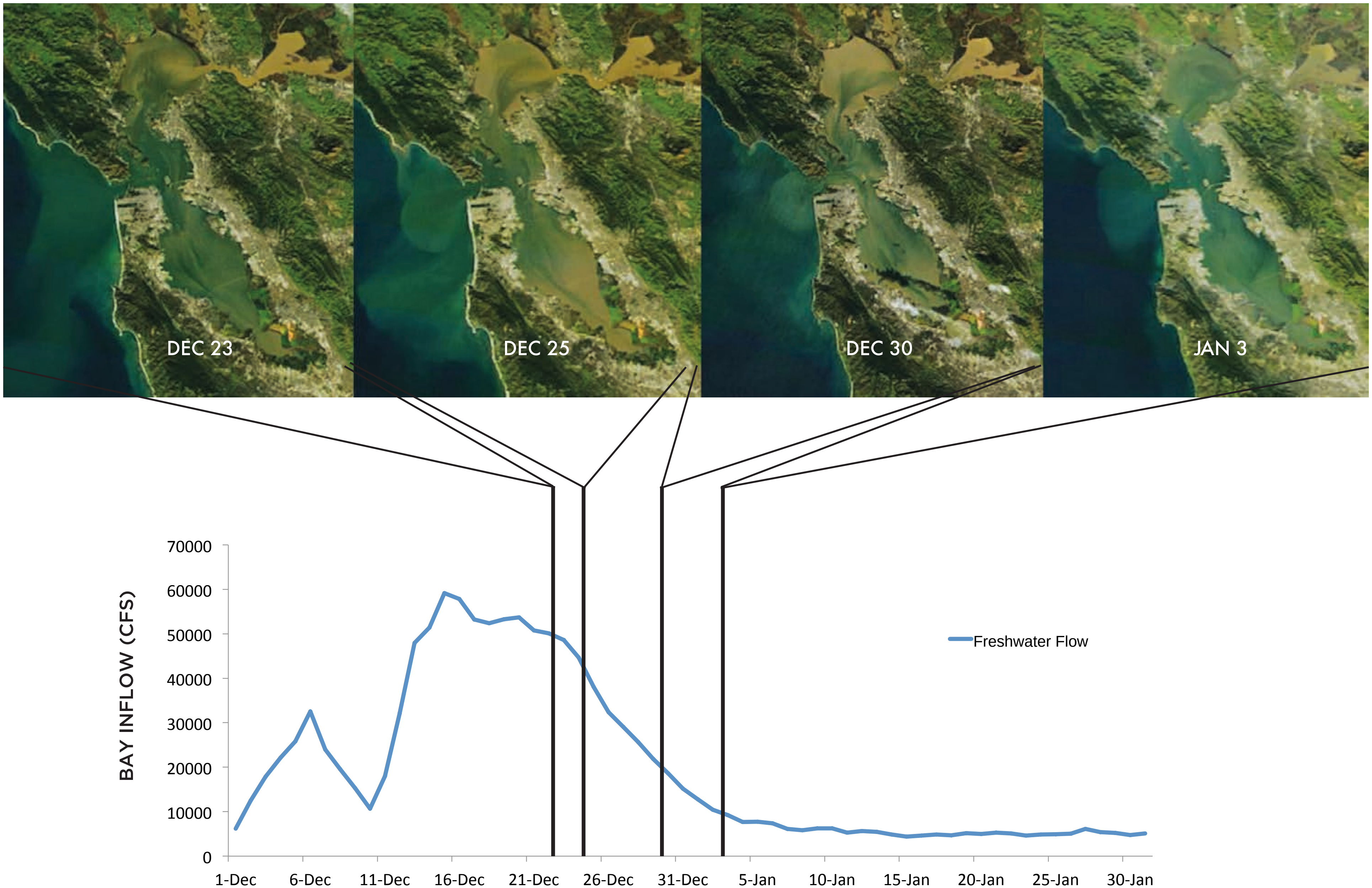
Moving water transports particles of varying sizes, from large gravel to silt to tiny bits of organic matter, collectively termed "sediment." In the Bay, the transport of sediment plays a vital role in the formation of habitats like marshes and beaches. In addition sediment-laden high flows contribute to the occurrence of cloudy, "turbid" water in the estuary's upper reaches, an important habitat attribute for many fish.

Water moves more sediment when it flows faster. In the Bay's watershed, most sediment is transported during high flow periods (Figure 7). Eventually the water slows down as it reaches the tidal parts of the estuary, with the heaviest particles settling out first. Sediment is deposited on the bottom of the Bay and in marshes along its edges. Sediment passing out the Golden Gate may remain suspended, settle to the ocean floor, or be deposited on nearby beaches.

LESS SEDIMENT REACHES THE BAY TODAY

Over time, humans have dramatically altered the amount of sediment delivered to the estuary, with significant ecological and human costs. In the 19th century, the amount of sediment reaching the Bay actually increased because of erosion from ranching, farming and hydraulic mining in the Sierra Nevada[42]. In recent times, however, far less sediment has flowed downstream – with major consequences for the Bay. Thousands of dams constructed over the past century and a half throughout the watershed now trap the flow of gravel, clay, sand and silt. Meanwhile, hundreds of miles of stream bank were engineered to limit erosion in the watershed. Submerged islands trap sediment in the Delta[43] and dredging of navigation channels removes sediment directly from the system[44].

FRESHWATER FLOW MOVES SEDIMENT INTO AND THROUGH THE BAY



Images from NASA

Figure 7: Peak flows of fresh water into the estuary carry sediment through San Francisco Bay and beyond. The graph above shows flow during a brief pulse of freshwater flow in the days following a December 2014 storm. When Bay inflows increase, a plume of suspended sediment is transported downstream, as seen in the satellite photos of San Francisco Bay from December 23, 2014 to January 3, 2015. Sediment suspended in the Bay's waters from these infrequent, but critically important, peak flow events is important for restoring tidal marshes and maintaining habitat for native fishes. Sediment supplies to the Bay and nearshore ocean have been limited by physical changes to the landscape (e.g., they are trapped behind dams and removed by dredging) and by elimination of the higher peak flows that could mobilize the sediments that remain. New projects to store or divert large amounts of water upstream of the Bay could siphon off more of the declining suspended sediment supply and further truncate the peak flows that carry that sediment downstream.

IT'S CLEAR – AND THAT'S THE PROBLEM

Capturing more water upstream and regulating downstream releases traps large volumes of sediment in reservoirs, limits erosion and overbank flooding along Central Valley rivers and tributaries, and reduces the frequency of flood events that would otherwise allow more sediment to reach the Bay[45]. Peak flows that can mobilize significant amounts of sediment occur much less often, and when they do, they carry much less sediment than previously[46]. Sediment input from the largest source in the Bay's watershed, the Sacramento River, declined by half between 1957 and 2001[47].

Many estuarine fish species respond to water turbidity – reduced visibility due to suspended sediments – in order to evade predators, find food, and move between habitat areas. Because the amount of sediments available for resuspension in the Bay has declined, turbidity has been dramatically decreased – by 36% in 1999[48] and by as much as 40% in the Delta[49]. The occurrence of clearer water is believed to expose highly endangered fish species like salmon and Delta smelt, and other organisms to increased risk from predators[50] and lost feeding opportunities[51].

FEEDING HUNGRY MARSHES AND BEACHES

A healthy sediment supply is crucial to the persistence of marsh and beach habitats throughout the estuary. As they become saltier due to reduced inflows, the brackish and freshwater marshes of the upper estuary require even larger amounts of sediment to maintain their physical form and elevation[52]. The problem is magnified by accelerating sea level rise, which will drown the Bay's existing wetlands unless they gain elevation. Maintaining low Bay inflows – or further reducing them – at the same time that sea levels rise, will ensure continued loss of this unique estuarine habitat. Reducing sediment inputs to wetlands undermines California's large-scale investment of time, money and energy to restore them.[53]. These and all types of wetlands are not just habitats for fish and wildlife; they also function as barriers against the effects of sea level rise on at-risk human communities and valuable infrastructure around the Bay; insufficient sediment inputs will make it more difficult to provide and maintain these barriers[54].

Bay inflows also transport sediments that feed and maintain local beaches, and these areas shrink or are lost as sediment inputs decrease. Twenty-three miles of sandy beaches in the Bay have been reduced to 7 miles, and most of the remaining beaches are in different locations than historical beaches[55]. Outside the Golden Gate, the coastline is the most rapidly eroding section in the state, with erosion accelerating 50% since the 1980s[56].

Baker Beach, Photo Credit: Christian Mehlführer

Although Bay inflow reductions aren't the only cause, they are an important contributor to the beach erosion problem. High Bay inflows can carry a lot of sand: at low flows, sand is a small percentage of the total sediment load in the Sacramento River, but it represents up to 70% of the total at high flows[57]. The loss of high flows into the Bay cuts off sand resupply to chronically eroding beaches throughout the Bay Area and along the open coast south to Pacifica (where most sediments have a Sierran origin, transported on flows from the Bay's watershed)[58]. Beach erosion in these areas removes habitat for many bird and invertebrate species, such as breeding populations of snowy plovers that require undisturbed beach area for nesting[59]. And, of course, people enjoy beaches too.

POLLUTION

Preventing pollution before it happens by eliminating or reducing toxic inputs to air, land, and water is always the best policy. In conjunction with that approach, maintaining adequate freshwater flow into the Bay helps to dilute the concentration of chemical and biological contaminants before they reach levels that are toxic and decreases the amount of time these substances spend in the Bay where the dilution factor is much lower than in ocean waters. Conversely, when freshwater flows are reduced for long periods, both naturally occurring and synthetic contaminants can increase to toxic levels.

TOXIC POLLUTANTS DO MORE HARM WHEN FLOWS ARE LOW

The amount of Bay inflow is known to significantly affect how readily available some heavy metals are to aquatic organisms like shellfish[60]. Silver and copper concentrations in benthic organisms in the South Bay typically decrease after winter inflows lower salinities, especially in years with higher flows. Reducing Bay inflows from the Central Valley could also reduce the effectiveness of processes that assimilate and neutralize waste in the South Bay[61].

Significant amounts of “legacy” contaminants from past mining and industrial practices are embedded in the Bay’s sediments, where they can be taken up by benthic organisms and then bioaccumulate in the foodweb. Over the past 20 years, for instance, mercury and PCB (Polychlorinated Biphenyl) concentrations in fish have persisted at high levels, limiting consumption of popular fish species[62], even long after being phased out from human use. Low flows can exacerbate the transfer of contaminants from the sediment to the food web; in Suisun Bay, for instance, the concentration of mercury in suspended sediment is higher at low Bay inflows (because waves resuspend bottom sediment) and lower at higher inflows[63].

Selenium is a naturally occurring element, essential, in trace amounts, for animal cell function. But it is highly toxic at even slightly higher doses, causing birth defects, reproductive failure, or death. The primary sources of selenium in the Bay’s watershed include discharges into the Bay from oil refineries and irrigation runoff from selenium-laden soils on the west side of the San Joaquin Valley.

Low flows promote uptake and integration of selenium into the food web[64]. Low flows are specifically correlated with higher selenium concentrations in clams[65]. As a result, diving ducks, sturgeon, and Sacramento splittail, which eat clams, can develop deformities and reproductive problems because of the elevated selenium levels associated with low flows[66]. Selenium concentrations in clams rise to a level of concern when Bay inflows are less than 7,000 cfs[67]; these extremely low Bay inflow levels occurred in 2014 and 2015 when the State of California relaxed minimum water quality and flow requirements in order to increase deliveries for agricultural irrigation in the Central Valley.

TOXIC ALGAL BLOOMS – CAN REDUCING FLOWS GENERATE NEUROTOXINS?

When freshwater flows are reduced to low levels, the estuary can become a good environment for harmful organisms that generate dangerous toxins.

Cyanobacteria (also known as “blue green algae”) are ancient photosynthetic ancestors of modern plants and algae. Some of the chemicals produced by cyanobacteria are extremely toxic to humans and wildlife. Periodic proliferation of certain cyanobacteria (such as Microcystis aeruginosa) are called “harmful algal blooms” or HABs. These blooms produce neurotoxins that can kill fish, aquatic mammals, waterfowl, and even dogs[68]. When these toxins get into drinking water supplies they are a real risk to human health.

Blooms of toxic cyanobacteria are occurring with increasing frequency in the upper estuary[69]. Toxins produced by HABs have been detected in invertebrates and fish throughout the entire estuary[70]. Organisms that are not killed outright by these toxins can transfer the poisons to their predators; the toxins become more concentrated as they move up the food chain (in a process known as “biomagnification”).

A recent review prepared for the California Environmental Protection Agency concluded that HABs in the Bay estuary are more frequent when water moves more slowly (increased residence time) and water clarity is high[71]; both of these conditions occur when inflows are low. The fact is that low flows not only fail to dilute or flush pollutants but also actually provide the very conditions that support the growth of organisms that generate powerful toxins. In this case, maintaining adequate inflows is a crucial element in preventing the creation of powerful toxins that threaten people and the environment.

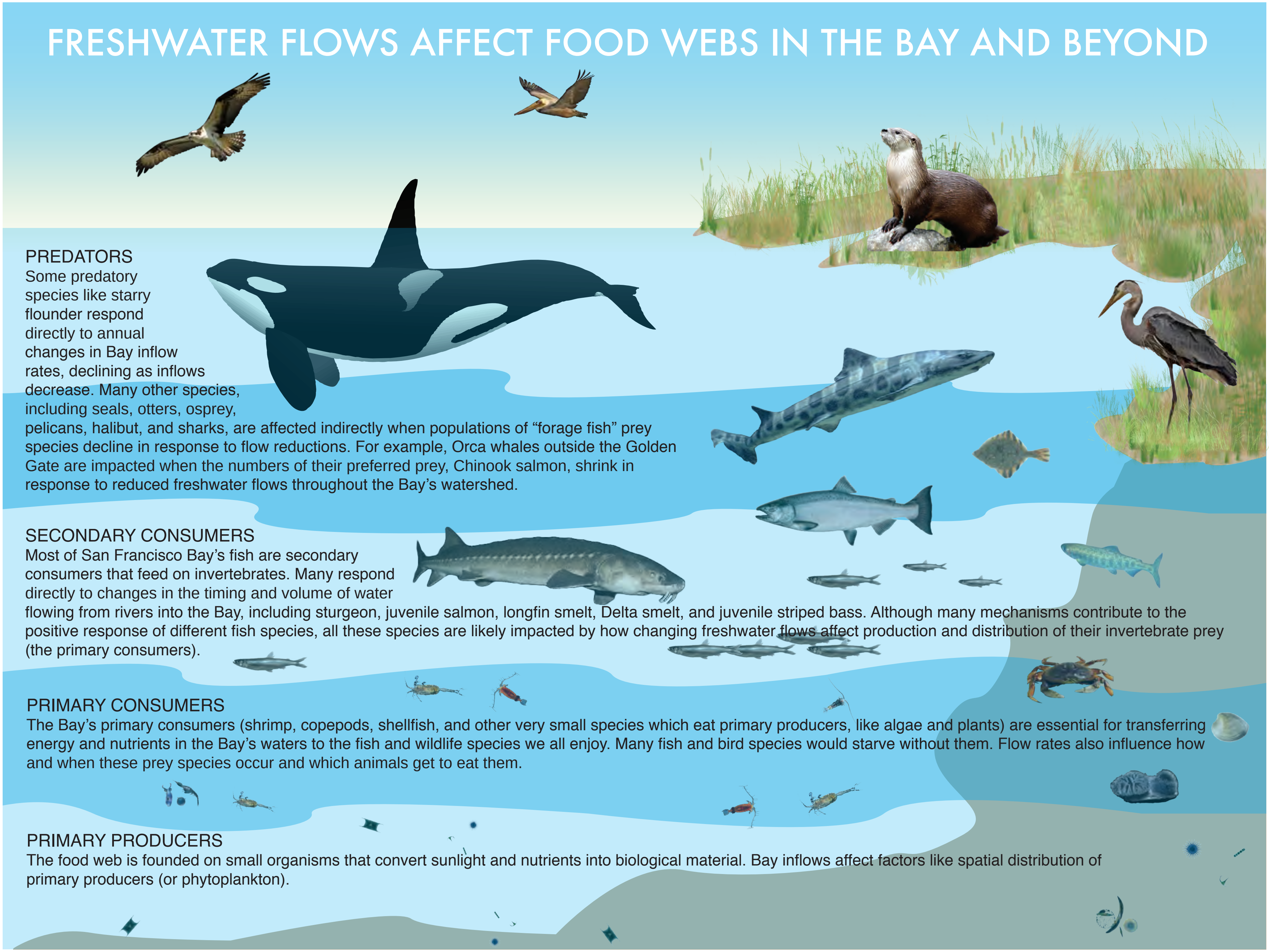
Cyanobacteria bloom, Photo Credit: US Geological Survey

FOOD WEB PRODUCTIVITY

Estuaries are highly productive nursery habitats for fish, birds, mammals, and invertebrates like crabs and shrimp. The San Francisco Bay estuary is no exception. Beginning in the 19th century, San Francisco was the center of major commercial and recreational fisheries for salmon, sturgeon, herring, smelt, rockfish, halibut, flounder, and crab. The Bay’s bounty played a large role in feeding the growing population of central and northern California and even Oregon.

Not surprisingly, this natural productivity depends on the many environmental processes that are driven or influenced by how much fresh water makes it to the estuary. As river flows reach the upper estuary, they slow down and spread out into a mosaic of shallow waters, mudflats and brackish and freshwater marshes; all of the critical inputs of nutrients, sediments and food the flow brings supports the growth of phytoplankton (tiny aquatic plants) and zooplankton (very small invertebrate animals), and a host of larger creatures that feed on them, in the water column and along the wetland margins. These freshwater and brackish habitats are more productive than the saltier ones downstream[72] and a large number of rare species are only found there[73]. Even though there are many factors that affect productivity, the science is clear that productivity of the food web in estuaries is closely tied to freshwater inflow[74], and that flow's stimulation of the food web has an important impact on survival and growth rates of many species[75].

One way to focus on how the estuary's food web works is to take a closer look at the production of juvenile Chinook salmon from the Bay's Central Valley watershed. Production of juvenile salmon emigrating from the Central Valley's rivers is strongly correlated with the amount and timing of freshwater flow[76]. River flows carry these young fish downstream to the estuary, along with the nutrients, sediments, and food that stimulate productivity. The estuary's muddy waters and wetlands (a result of sediments transported from upstream) provide cover and abundant food that allow the young salmon to survive and grow, along with other small fish and invertebrates. Some of the young salmon become prey for larger species, including birds and mammals. The survivors migrate on currents driven by inflows and the tides, and some become food in distant parts of the estuary, even outside the Golden Gate. The juvenile Chinook salmon produced in the Bay's watershed eventually become one of the primary food items in the diet of the Orca whales that reside in the Gulf of the Farallones[77]. This means that even creatures that rarely enter the Bay rely on the productivity of the food web driven by the amount and seasonal timing of Bay inflow (Figure 8).


FRESHWATER FLOWS AFFECT FOOD WEBS IN THE BAY AND BEYOND
PREDATORS
Some predatory species like starry flounder respond directly to annual changes in Bay inflow rates, declining as inflows decrease. Many other species, including seals, otters, osprey, pelicans, halibut, and sharks, are affected indirectly when populations of “forage fish” prey species decline in response to flow reductions. For example, Orca whales outside the Golden Gate are impacted when the numbers of their preferred prey, Chinook salmon, shrink in response to reduced freshwater flows throughout the Bay’s watershed.
SECONDARY CONSUMERS
Most of San Francisco Bay’s fish are secondary consumers that feed on invertebrates. Many respond directly to changes in the timing and volume of water flowing from rivers into the Bay, including sturgeon, juvenile salmon, longfin smelt, Delta smelt, and juvenile striped bass. Although many mechanisms contribute to the positive response of different fish species, all these species are likely impacted by how changing freshwater flows affect production and distribution of their invertebrate prey (the primary consumers).
PRIMARY CONSUMERS
The Bay’s primary consumers (shrimp, copepods, shellfish, and other very small species which eat primary producers, like algae and plants) are essential for transferring energy and nutrients in the Bay’s waters to the fish and wildlife species we all enjoy. Many fish and bird species would starve without them. Flow rates also influence how and when these prey species occur and which animals get to eat them.
PRIMARY PRODUCERS
The food web is founded on small organisms that convert sunlight and nutrients into biological material. Bay inflows affect factors like spatial distribution of primary producers (or phytoplankton).

HARD TIMES FOR THE UPPER ESTUARY FOOD WEB

Freshwater flows into the estuary are an extremely powerful driver of productivity in northern San Francisco Bay and the Delta. Over many decades, scientists have documented strong and persistent statistical relationships between winter – spring inflows and the abundance of major invertebrate prey populations like Bay shrimp[78]. In years with low inflows, Bay shrimp biomass correspondingly declines[79]. Under natural runoff patterns, inflows are high enough in most years to support a productive ecosystem. The human-made "permanent drought" experienced in the Bay, however, in combination with other factors, has had catastrophic effects on the food web. Primary production in the Delta declined 43% between 1975 and 1995[80]. One flow-related factor is the long-term decline in suspended solids entering the estuary on peak inflows, and the resulting increase in water clarity, which increases predation risk for many species. Another factor driving the decline in food web productivity is the almost complete loss of fresh water inflow from the San Joaquin River basin portion of the Bay's watershed[81] (most of which is either diverted upstream or exported by the giant Delta pumps).

Figure 8: San Francisco Bay and the nearshore ocean support an incredible array of fish, bird, mammal, and invertebrate species that are linked together in a complex food web. Freshwater flows into the estuary have direct effects on the productivity of this food web – major decreases in fresh water flows and/or changes in the timing of that flow lead to smaller populations of many key organisms. The creatures that feed on these "flow-dependent" species, including birds and mammals that live in the nearshore ocean, are indirectly impacted by declines in their food supply. Human water diversions in the Bay's watershed have had measurable (and often dramatic) negative effects on the food web of San Francisco Bay and the nearshore ocean.

Overbite clam

Photo Credit: Luis A. Solórzano

An additional alteration to the Bay's food web is invasion by exotic (non-native) species, which can displace native fish and wildlife populations[82]. Reduced inflows favor the spread of invasive species[83], probably because flow reductions undermine the ability of native species to dominate their historical habitats. The extent of change varies by location, with the biggest changes in the historically fresh and brackish portions of the upper estuary, which are increasingly dominated by invasive species over time[84]. The most dramatic example of food web alteration by an exotic species is the colonization of this region in the 1980s by the overbite clam; this one species filters large amounts of phytoplankton from the water column, leaving less energy available for all the other species that feed on plankton or its consumers. The overbite clam invasion coincided with a dry period when reservoir operations and water diversions prevented more than three-quarters of the Central Valley's winter-spring unimpaired runoff from reaching the Bay[85]. The conjunction of these stressors has been implicated in multiple changes in the structure and functions of the upper estuary's low salinity zone[86].

Despite these major changes, many fish and zooplankton of the upper estuary continue to respond positively when estuary inflows increase because the flow-related mechanisms that drive their productivity have not changed[87]. In addition, the effect of the overbite clam may be ameliorated at higher flow levels as their abundance fluctuates in response to salinity changes[88], with the population responding to shifts in the extent and location of the low salinity zone[89]. Indeed, increases in freshwater flow may help control a wide range of nuisance species in the estuary, such as Brazilian waterweed (*Egeria densa*), toxic algae, jellyfish, clams, and inland silverside[90].

To make matters even worse in the post-invasion world, declining inflows in recent years have facilitated the occurrence of harmful algal blooms of cyanobacteria in the Delta and upper estuary. When such blooms occur, they can change phytoplankton community composition and toxin levels[91]. The new fact on the ground is that the loss of inflows has not only been undermining the ability of the food web to support native species in the upper estuary, but now it is actually helping create a new food web that is toxic to fish, wildlife and humans.

THE FAR SIDE: PLANKTON IN THE SOUTH BAY AND OUTSIDE THE GOLDEN GATE

Because fresh water is less dense than saltier water, freshwater inflow from the upper estuary rides on the surface of the water column as it enters the South Bay in the spring. This sets up strong density-driven currents in the South Bay[92], which in turn provide the right conditions for a spring plankton bloom[93]. When South Bay waters become stratified during and after these spring inflows, sun penetrates the fresher surface waters allowing algal cells to grow[94], unchecked by the large population of grazing organisms that live on the bottom of the Bay[95]. How large these plankton blooms are "is directly related to the intensity and duration of river-driven density stratification"[96], and when Bay inflows are very high exceptionally large blooms occur as a result[97].

As mentioned earlier, the surface plume of brackish water that flows out the Golden Gate in winter and spring creates a highly productive environment that makes an important contribution to the richness of the marine ecosystem in the Gulf of the Farallones National Marine Sanctuary[98]. The plume front creates a food-rich habitat where invertebrates, fish, birds, and marine mammals all converge to eat and be eaten. Flows into the Bay and then onward to coastal waters also directly facilitate the transport of nutrients and organisms and cue stages in the outmigration of juvenile Chinook salmon and other fish which are important food sources for marine mammals like Orca whales.

Orcas near Golden Gate Bridge
Photo Credit: Jennifer Hagerty

Chinook salmon Photo Credit: Bay.org

WHO SUFFERS FROM THE BAY'S STARVATION DIET?

HOW FISH, WILDLIFE, AND PEOPLE ARE HARMED BY A FRESHWATER-STARVED BAY

Every day, the seven million of us who live in the Bay Area can enjoy San Francisco Bay by walking along its shores, gazing at it from our cars, homes, or offices, or by swimming in or boating on its waters. Each year, more than twice that many people visit the region to enjoy this spectacular estuary, its waters, and its natural bounty. The benefits that people derive from vibrant fish and wildlife populations, good water quality, and diverse natural settings are all tied to making sure enough fresh water makes it into the Bay. In other words, Bay inflow isn't just good for the Bay ecosystem but is one of the foundations for the quality of life and the strength of the economy in the Bay Area.

The San Francisco Bay estuary supports some 750 species of plants and animals, and many more are found throughout its vast watershed. Nowhere else on Earth do so many distinct types of Chinook salmon use one place as a migratory corridor and juvenile rearing area. The Bay's wetlands are home to over a million waterbirds, including many unique native species, and an important food source and resting place for millions of migrating birds. These species all evolved in response to predictable natural patterns of inflow to the Bay.

Cold freshwater flows in rivers throughout the Bay's watershed provide excellent conditions for spawning of a wide range of fish species, like Chinook salmon, Sacramento splittail, green and white sturgeon, and steelhead. The emerging year-class of juvenile fish then migrate into the Bay where they join a complex food web of resident and migratory species living in the open waters, wetlands, and nearby terrestrial habitats. Most species in the Bay are affected in some way by the freshwater pulses that flow through it and mix with its more saline marine waters (Figure 9). As explained in the previous chapter, all the critical processes that make the Bay estuary a productive place for fish and wildlife – from the transport of fish, food, nutrients and sediments in Bay inflow to the formation of low salinity zones, wetlands and beaches – are shaped by how much freshwater flow arrives, when it arrives, how frequently it occurs, and how long it lasts. There are many examples, unfortunately, of what happens when the flow is no longer big enough, doesn't last long enough, isn't frequent enough, or doesn't occur at the right time.

WHAT DO THESE SPECIES HAVE IN COMMON?

SPECIES	NATIVE?	LIFE SPAN (YEARS)	RESIDENT/ MIGRATORY/ NURSERY REARING	REPRODUCES WHERE?	ABUNDANCE CORRELATED WITH FLOW?
Chinook Salmon	Yes	3-5	Anadromous	River	**YES**
Striped Bass	No	4-10	Anadromous	River	**YES**
Green Sturgeon	Yes	Decades	Anadromous	River	**YES**
Delta Smelt	Yes	1	Resident	Delta	**YES**
Longfin Smelt	Yes	1-3	Resident/ Migratory	Delta/ Suisun	**YES**
Starry Flounder	Yes	7-8	Nursery Rearing	Ocean	**YES**
Sacramento Splittail	Yes	5-7	Resident	Shallow Freshwater	**YES**
American Shad	No	5-7	Migratory	River	**YES**
Staghorn Sculpin	Yes	1-3	Resident	Ocean/ Estuary	**YES**
Leopard Shark	Yes	Decades	Nursery Rearing	Ocean/ Bay/ Estuary	**YES**
Bay Shrimp	Yes	1.5-2.5	Nursery Rearing	Ocean	**YES**

Figure 9: The relationships between freshwater flow and species abundance are widespread. The specific mechanisms by which flow affects abundance, and the relative importance of mechanisms are likely to vary for different species (Kimmerer 2002b); however, the strong, significant correlations that persist across decades of monitoring provide powerful evidence of the benefits of freshwater flow to San Francisco Bay's fish and wildlife populations.

VIABLE POPULATIONS OF FISH AND WILDLIFE NEED FRESH WATER

The massive transformation of the Bay's watershed by tens of thousands of dams, canals, pumps, and wells has changed the patterns of flow to the Bay so much that the current conditions bear little resemblance to those in which the Bay's native fish and wildlife evolved. The result is a system where native species are in decline – some very close to extinction – while nuisance non-native species increasingly take advantage of the altered ecosystem.

Populations of many aquatic organisms at different levels of the food web have sharply declined, and six native fish species - Delta smelt, longfin smelt, steelhead, green sturgeon, and the winter and spring runs of Chinook salmon – that used to be among the most common in the estuary are now listed as in danger of extinction by the federal government and/or the State of California (Figure 10). To have viable populations, these species need to be:

• *abundant* (have enough individuals to ensure long-term survival through a range of different conditions)

• *diverse* (have enough variation among individuals to ensure that some will respond successfully to changing environmental stresses)

• *productive* (able to grow the population fast enough to exploit good conditions in a variable environment); and

• *spatially distributed* (exist in a large enough area to avoid catastrophic localized pressures).

American shad   Photo Credit: Brian Currier

COLLAPSE OF SPECIES ACROSS MULTIPLE TROPHIC LEVELS

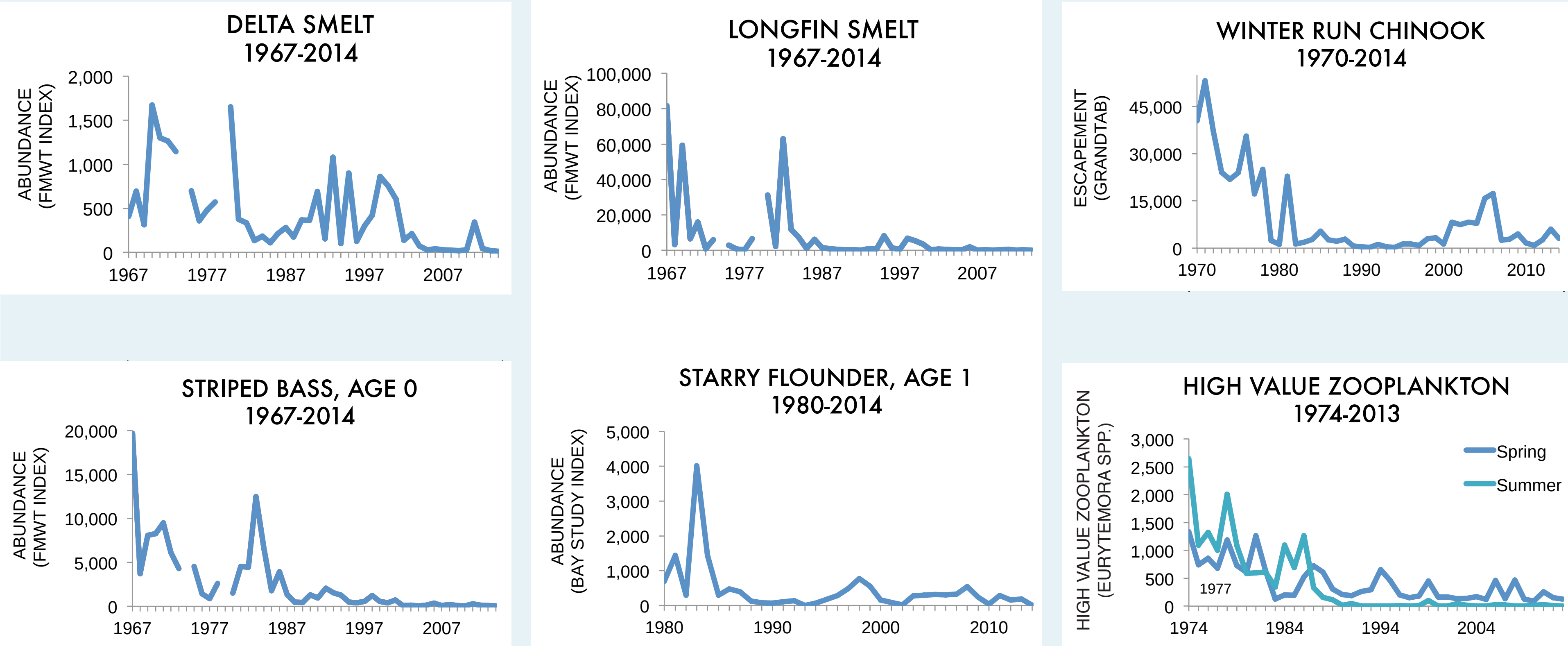


Figure 10: Abundance trends of several populations that serve as key indicators for the health of the San Francisco Bay estuary and its watershed. Data sets and length of data time series differ across species.

Many populations that use the San Francisco Bay estuary as a nursery or migration pathway are in severe decline. These declines pre-date, but have been exacerbated by, water management actions during the current drought.

Data provided by: California Department of Fish and Wildlife's Bay Study, Fall Midwater Trawl, Zooplankton Study, Anadromous Resources Assessment and the Interagency Ecological Program for the San Francisco Estuary

The outlook for these populations is grim in large part because Bay inflows are no longer adequate to maintain the services the Bay ecosystem once provided to support abundant, diverse, productive and spatially distributed populations.

One of the best-documented facts about the estuary is the strong, persistent relationship between freshwater flow and healthy populations of key species. Over the past few decades many scientific studies have documented the critical role freshwater flows play in maintaining viable populations of native fish and wildlife, and the productive habitats and food webs that support them, in estuaries in general and the San Francisco Bay estuary in particular[99]. This overwhelming body of evidence has led federal and state regulators and resource managers, as well as numerous scientific review panels, to conclude that current freshwater inflows to the Bay estuary are no longer adequate to sustain native fish and wildlife populations[100].

ABUNDANCE: LESS FLOW, LESS FISH

Obviously, the more individuals of a particular plant or animal species there are, the less vulnerable that species is to extinction risks from natural or human disturbances like habitat destruction or toxic pollution. Native fish species such as Delta smelt, longfin smelt, and Chinook salmon were among the most abundant species in the Bay ecosystem until the second half of the 20th century, but are now among the most rare species, and altering and reducing flows has been the main reason for their decline.

How much Bay inflow there is during critical times in fish life cycles strongly affects abundance: Critical parts of the life cycle of many fish species in the Bay estuary – such as reproduction, growth, and migration – are timed to occur during the winter and spring months because the inflow from rainfall and snowmelt during this period was naturally higher, creating beneficial habitat conditions. The amount of timing and flow in any winter – spring period has a large effect on how populations of these species respond during the months and years following[101] (Figure 11).

During the winter and spring, the migration of juveniles of fish species like Chinook salmon, steelhead, and sturgeon is cued by rising flow levels, and the young fish make their way along with the flow from their natal rivers through the estuary to the ocean. More Chinook salmon survive the journey when flows are higher[102].

At the same time, small forage fish like Delta smelt and longfin smelt, important parts of the estuary food web, respond to increasing flows by moving to spawning areas in the upper estuary and breeding. Longfin, once the most common native fish residing in the estuary and now one of the rarest, respond dramatically to flow changes – their abundance is tightly and positively correlated to winter – spring Bay inflows[103]. No other factors, including the impact of invasive species, appear to affect longfin population dynamics during the first few months of life[104].

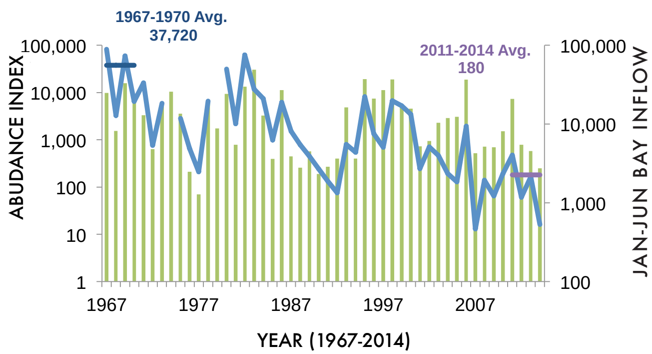
During the spring months young starry flounder (another species caught by recreational and commercial fishermen) migrate into the Bay estuary from the ocean to mature[105]. The number of one-year-old starry flounder rearing in the estuary in a given year is strongly correlated to the amount of freshwater inflow in the previous spring[106].

DECLINING BAY INFLOWS = DECLINING FISH POPULATIONS

Figure 11: Strong correlations between abundance (blue lines, left vertical axis; abundance indices from biological sampling programs) and winter-spring inflow into San Francisco Bay (green bars, right vertical axis; "Bay Inflow") have persisted for many decades for fish species and their invertebrate prey. Longfin smelt were once the estuary's most common resident fish and a key component of a commercial smelt fishery; this population has declined by orders of magnitude and is strongly and significantly correlated with freshwater flow rates. Starry flounder, a predatory fish, generally increase in years following those with high freshwater flows into the estuary. Bay shrimp are prey for smelt, flounder, and a host of other fish and bird species; their population tracks closely with springtime Bay inflows.

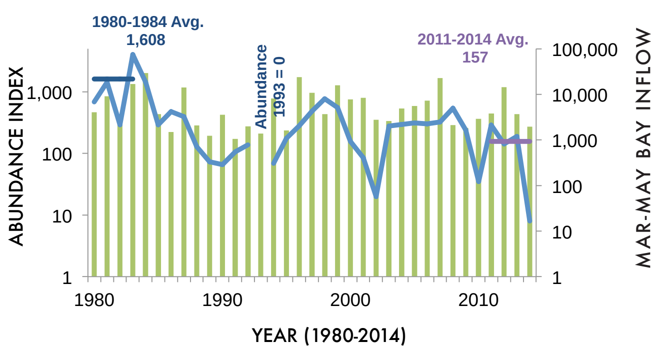
Bay Inflow
Abundance Index

LONGFIN SMELT



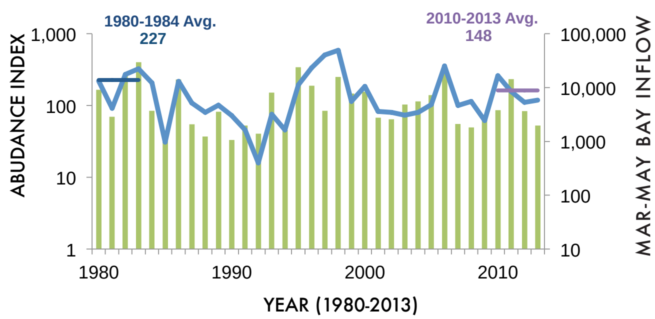
Longfin smelt - Recent average decline 99.5%

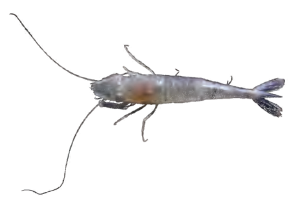
STARRY FLOUNDER



Starry flounder – Recent average decline 90%

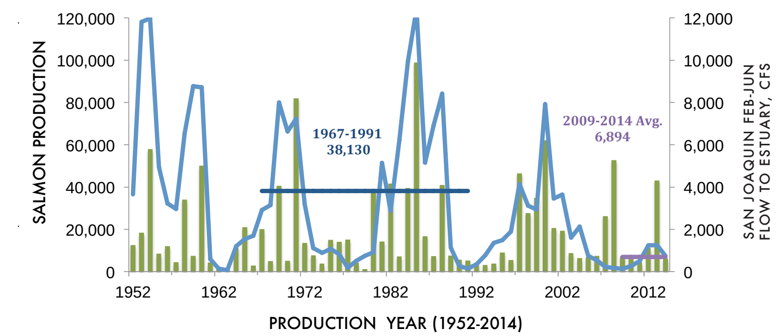
BAY SHRIMP





Bay Shrimp - Recent average decline 35%

SAN JOAQUIN RIVER CHINOOK SALMON PRODUCTION



San Joaquin River Flow during juvenile migration

San Joaquin River Chinook Production (measured in the ocean 2 years later)

Chinook salmon - Recent average decline 89%

Chinook salmon production (the estimated number of fish from a given watershed that reach age-2 in the ocean) is highly correlated with freshwater flow rates that occurred when juvenile salmon migrated to the ocean, two years earlier. The figure matches production of naturally spawned Chinook salmon from the San Joaquin River with the river's flow to the estuary two years earlier, during outmigration of that same cohort of fish.

Many other species produce a significant and persistent population response to winter – spring inflows, from the smaller organisms and other zooplankton that fish feed on, such as shrimp[107] to the popular non-native sportfish like striped bass and American shad that once thrived alongside native species[108], and from the estuary's brackish upper reaches to as far away as the South Bay[109].

While the population effects of inflow to the estuary are most noticeable in the winter and spring, the effects are not limited to these seasons. The endangered Delta smelt, a small native fish found nowhere else in the world which used to be one of the most common fish in the estuary, benefits from increased area of brackish habitat that forms when fresh water reaches the upper estuary in September and October[110]. The adult Chinook salmon that successfully survived their journey to and through the ocean rely on the same fall inflows to provide adequate water quality conditions for their return migration[111] and help orient them towards their native spawning grounds[112].

Exporting Bay inflows (and fish) into giant pumps also cuts down on abundance: In the Delta region of the upper estuary, giant pumps operated by the federal Central Valley Project and State Water Project export water for use by irrigators in the San Joaquin Valley and cities in Central and Southern California. These pumps are so powerful that much of the Bay inflow is drawn toward the interior Delta, and along with it fish and invertebrates, and their eggs and larva. More than 9,000,000 fish on average are screened out of water to be exported by the pumps each year; though this process is called *"salvage,"* most of these fish will die before or shortly after they are released back into the Delta[113] (Figure 12). The real impact of salvage is actually much larger because larval fish are not counted and most small fish die (typically in the mouths of predators) before they reach the salvage facilities. In drier years, these export impacts can have a devastating impact on fish abundance, taking up to 40% of the annual population of Delta smelt (which live only one year) and up to 15% of outmigrating juvenile Chinook salmon[114].

Starry Flounder is one of many fish species that respond positively to increases in freshwater flow into San Francisco Bay. Dramatic reductions in Bay inflow jeopardize the recreational and commercial fisheries for this species. Photo Credit: David Csepp, NMFS/AKFSC/ABL

How much Bay inflow there is can help or hinder the spread of non-native species: The Bay estuary is one of the most highly invaded estuaries in the world, and the radical alteration of Bay inflows is believed to be a primary factor in successful colonization by invasive non-natives. The abundance of many non-native species shifts in inverse proportion to flow. For example, an extended drought in the 1980s coinciding with then record high levels of water diversion facilitated the establishment and explosive spread of the overbite clam. When, in contrast, Bay inflows increase, invasive clams and fish such as the small but voracious inland silverside decreases in abundance[115].

NUMBER OF FISH SALVAGED AT THE STATE AND FEDERAL PUMPS IN THE DELTA 1993 – 2011

STATUS KEY

- Endangered - Federal
- Endangered - California
- Threatened - Federal
- Threatened - California

LEGEND

- Native to CA
- Recent decline
- Important Fishery
- Commercial/Sport Fisheries Destroyed
- Protection Removed (for political reasons; species has not recovered)

Figure 12 Fish were selected to encompass the wide range of species and life history types that are affected by water pumps.

"Average annual salvage" is mean yearly salvage from 1/1993 through 12/2011; "Maximum salvage" is the value for the calendar year with the highest salvage numbers (years differ amoung species).

These numbers underestimate the actual fish kills by not counting the fish that slipped through the bypass system and were killed by the pumps, and by not including indirect mortality. "Yearly Total" refers only to the 20 species listed.

SELECTED FISH SPECIES	1993-2011 Average	ANNUAL SALVAGE Maximum	STATUS
American shad	1,022,700	2,510,184	Important Fishery; Recent decline
Bluegill	127,133	394,952	
Channel catfish	45,799	131,484	
Chinook salmon (winter run)	51,955	183,890	Endangered - Federal; Endangered - California; Native to CA; Commercial/Sport Fisheries Destroyed; Recent decline
Chinook salmon (spring run)			Threatened - Federal; Threatened - California; Native to CA; Commercial/Sport Fisheries Destroyed; Recent decline
Chinook salmon (fall run)			Native to CA; Important Fishery; Recent decline
Chinook salmon (late-fall run)			Native to CA; Important Fishery; Recent decline
Delta smelt	29,918	154,820	Threatened - Federal; Endangered - California; Native to CA; Recent decline
Green sturgeon	58	363	Threatened - Federal; Native to CA; Recent decline
Inland silverside	62,838	142,652	
Largemouth bass	54,180	234,198	Important Fishery
Longfin	6,228	97,686	Threatened - California; Native to CA; Recent decline
Prickly sculpin	76,403	274,691	Native to CA
Steelhead (Rainbow trout)	5,278	18,580	Threatened - Federal; Native to CA; Commercial/Sport Fisheries Destroyed; Recent decline
Redear sunfish	1,609	5,611	
Riffle sculpin	155	798	Native to CA
Sacramento sucker	3,443	27,362	Native to CA
Sacramento splittail	1,201,585	8,989,639	Threatened - Federal; Native to CA; Important Fishery; Recent decline
Striped bass	1,773,079	13,451,203	Important Fishery; Recent decline
Threadfin shad	3,823,099	9,046,050	Recent decline
White catfish	296,543	941,972	
White sturgeon	151	873	Native to CA; Important Fishery; Recent decline
Yellowfin goby	193,399	1,189,962	

AVERAGE YEARLY SALVAGE TOTAL: 9,237,444

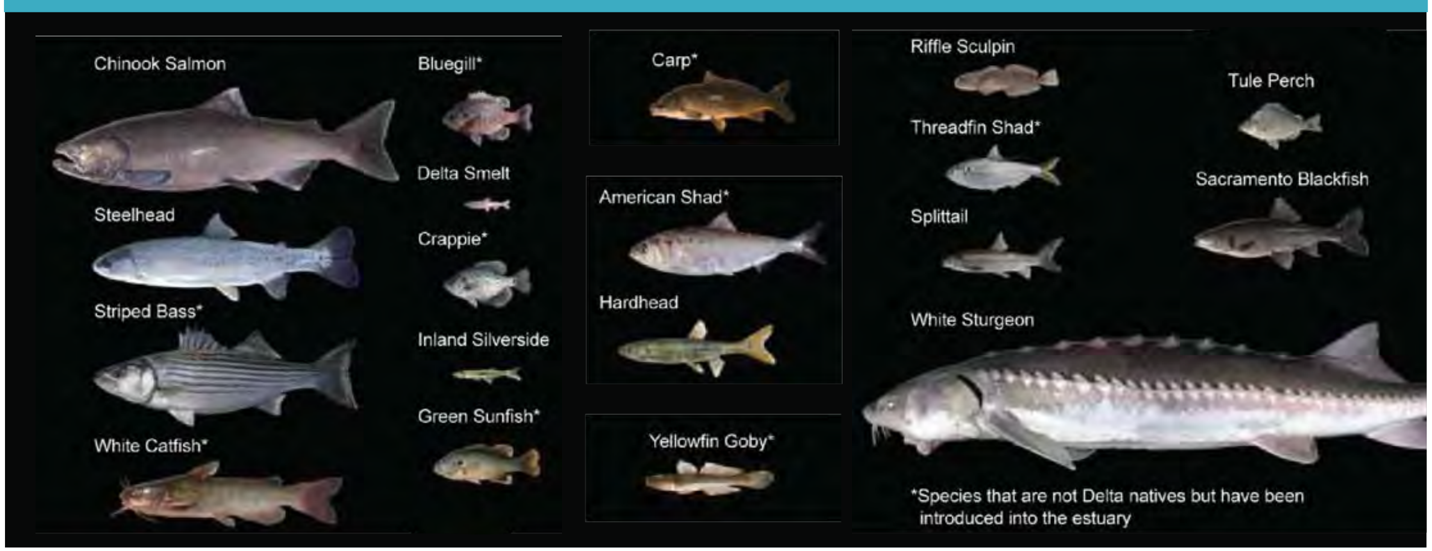
DIVERSITY: IT'S ALL IN THE TIMING

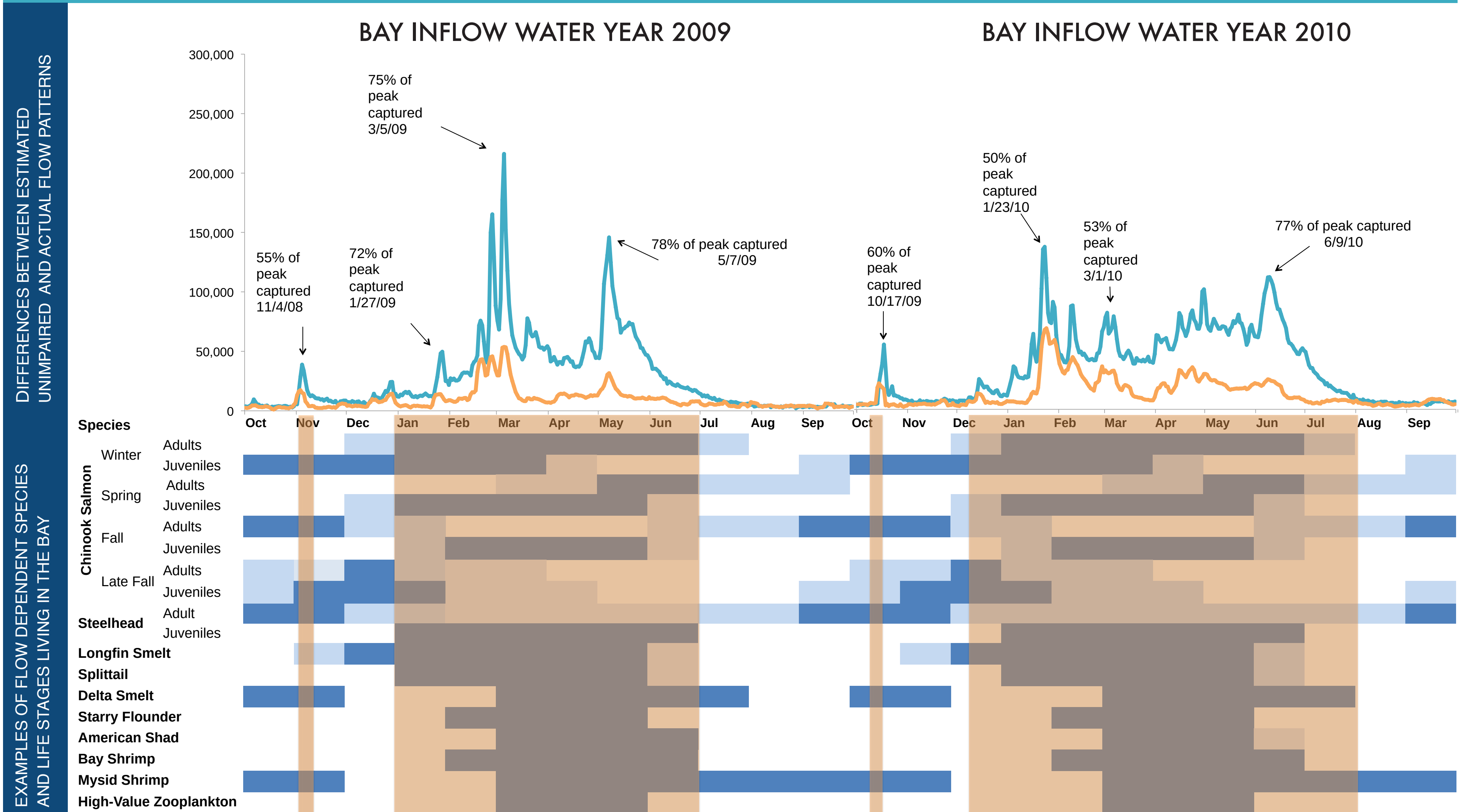
"Don't put all your eggs in one basket" is common advice for investors. Likewise, populations comprised of diverse individuals that exhibit a range of life history behaviors and genetic predispositions are more resilient to environmental disturbances of all kinds and less vulnerable to the risk of extinction. California's natural regime of extended winter rains and spring snowmelt and high year-to-year variability favors a wide variety of responses by the individuals within a population. Constraining the volume and timing of peak flows year after year selects for a small segment of behavioral and ecological responses that are able to utilize habitats during limited windows of availability (Figure 13). For instance, the dramatic decline of Bay inflows in the winter and spring limits the spawning period for Delta smelt, making the fish less able to capitalize on good conditions that may occur during the multi-month spawning and rearing seasons[116]. When the window of suitable spawning conditions for Delta smelt is reduced and limited to the same narrow timeframe year after year, some rare but valuable life-history strategies no longer pay off. The genetic variants that allow for these different strategies may decline or even disappear – meaning that the population's ability to grow is compromised, even when good conditions return[117].

Hedging your bets is the best way to plan a migration: Chinook salmon experience a similar dilemma. Historically, different juvenile migration strategies have succeeded under different conditions[118]. But, as shorter and less frequent peak flow periods and lower flow volumes occur with increasing regularity during their juvenile migrations, the salmon life history types that can survive such conditions are favored over other life-history types. The period when flows are provided to support the outmigration of juvenile fall-run Chinook salmon from the San Joaquin River (the state's second largest river) is limited to one month, and even that requirement was relaxed during the recent drought.

Restricting the migration window and limiting the flows that cue migration undermines the life-history diversity (in this case, the size and time at which juveniles migrate) that have allowed Chinook salmon to survive natural (and extreme) fluctuations in

SPECIES OF FISH COMMONLY COLLECTED AT THE STATE FISH SALVAGE FACILITY PHOTO: CA DWR



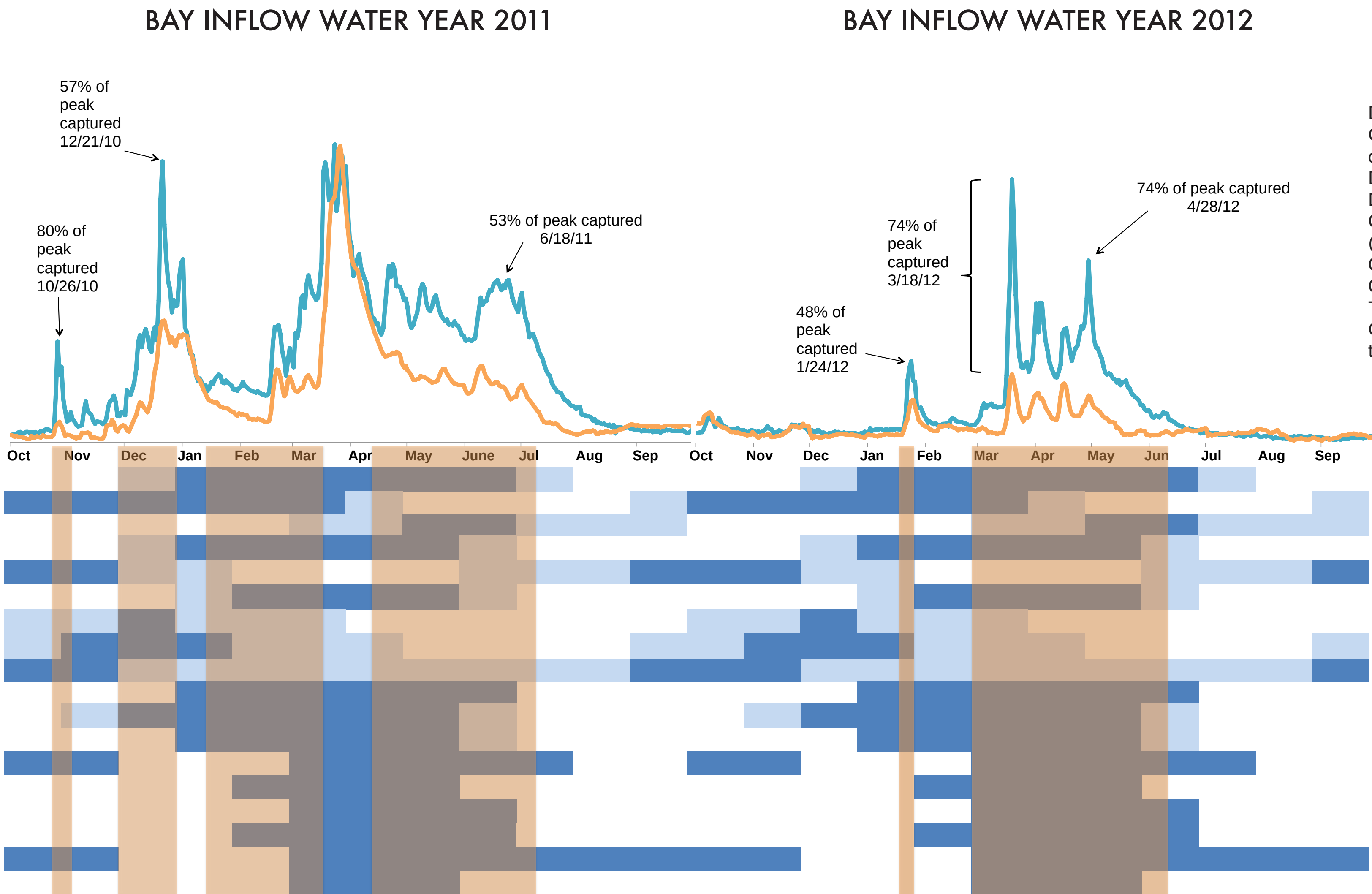


Only 28% of the Central Valley watershed's runoff made it to the Bay between February and June 2009, the lowest percentage of available flow since 1990. Peak flow events in January, February, March, and early May were virtually eliminated; this deprived juvenile salmon (all four distinct populations) and numerous other species of the ecological benefits associated with these short-term pulses of fresh water.

Sixty-five percent of Central Valley runoff was diverted during the winter-spring of 2010, and high percentages were diverted during peak flow periods that species like Chinook salmon rely on to find their way through the Delta to the Ocean.

Figure 13: Overlap in timing of freshwater flow and presence of different species life-stages in San Francisco Bay and the Delta. Top panels show, for years 2009-2012, the rate of freshwater flow into the Bay (Bay Inflow, orange line) in comparison to what would have flowed had there been no dams or diversions upstream of the estuary (unimpaired flow, blue line). Lower panels show the seasonal timing of several species that use the estuary to

FLOW AND SPECIES 2009-2012



Data sources: California Department of Water Resources Dayflow and California Department of Fish and Game Report, 2010 (Quantifiable Biological Objectives and Flow Criteriafor Aquatic and Terrestrial Species of Concern Dependent on the Delta).

Even when wet conditions returned in 2011, most of the winter flows were captured until Central Valley reservoirs were filled in March. After that, runoff was allowed to reach the estuary. Fish and wildlife usually receive their share of life-giving flows only when humans run out of space to store extra water.

When dry conditions returned in 2012, most of the available fresh water runoff was diverted again. Only 38% of the critical winter-spring flows reached the estuary, plunging the Bay's ecosystem back into a severe, man-made drought. Again, species like salmon and splittail were deprived of the short-term peak flows upon which they rely.

complete their life cycle (light blue bars indicate when a life stage may be present; dark blue bars indicate the life stage is definitely present at that time). The overlap between species presence and periods when flow volume was significantly reduced by water diversions and exports in each year (red shading) reveals likely impacts of Central Valley water management on major fish and invertebrate populations in San Francisco Bay.

their environment for millennia. This loss of diversity in juvenile migration strategies likely led to the unprecedented closures of California's ocean fishery in 2008 and following years[119]. The net effect of reducing migration diversity is to gamble that a small subset of the fish that migrate during such short windows will reach the ocean exactly when food supplies, temperatures, and other conditions are adequate. Salmon thrived in the Bay estuary by hedging their bets about when to go to the ocean; restricting those opportunities eliminates large portions of the population that might capitalize on changing conditions, and makes the dwindling remnant much more susceptible to extreme population swings.

PRODUCTIVITY

In the context of what defines a viable population, productivity refers to a population's ability to grow; it is the balance between birth rate and death rate. Populations that have a high capacity for population growth can rebound quickly after periods with poor environmental conditions[120]. In estuaries, both river inputs and ocean conditions affect productivity of different species to different degrees. Scientific research in the Bay estuary suggests that freshwater inflows have greater ecological effects on this particular estuary than the effect of ocean waters moving inland into less saline environments[121] (Figure 14).

As with abundance, there is strong scientific evidence linking population growth in native fish species like longfin smelt and Chinook salmon to freshwater inflows to the estuary[122]. In the variable conditions that typify an estuary, many aquatic organisms evolved to rebound rapidly in wetter years following poor conditions in drier years. But these species must now contend with the Bay's human-made "permanent drought". In terms of the actual conditions experienced by the estuary's fish and wildlife, wet years are infrequent and much less wet, and drier years are extremely dry and nearly continuous. As a result, in most years the population's rate of growth is constrained, and the higher flows that would allow the population to rebound rarely occur.

Food web productivity also improves with increases in freshwater flow to the estuary. Productivity in this sense has been degraded by the direct and indirect effects of reducing inflows, as described in the previous chapter. One of those effects is the successful establishment of invasive species, whose growing numbers can displace native fish and wildlife populations by competing for food and habitat. The effects are not confined to the winter and spring months. For example, the prevailing theory about why anchovies are no longer abundant in the upper estuary in summer and fall is that the local population simply left the area when food web productivity was reduced[123]. This effect has been attributed to the effect of the overbite clam on production of anchovy prey; however, the clam's invasion itself appears to have been facilitated by the extreme reduction in inflow. Species such as Pacific herring feeding in the summertime may also be negatively affected by reduced food web productivity in the Bay[124].

Salmon   Photo Credit: Bay.org

GENERALIZED MODEL OF BAY FISH ABUNDANCE

	SPAWNING SUCCESS		JUVENILE AND ADULT SURVIVAL				
ECOLOGICAL FEATURE	FECUNDITY	SPAWNING HABITAT	PREY DENSITY	DISEASE	CONTAMINANTS	PREDATION	REARING HABITAT
IS THE PRODUCT OF...	Flow and ocean conditions affect prey abundance in the Bay which can affect female growth and body size	Suitable spawning substrate with appropriate temperature, salinity, and flow rate	Water temperature, nutrient and food transport, productivity of microscopic organisms, contaminants, disease	Water temperature, flow rates through the estuary (residence time), fish distribution	Toxin concentrations, frequency of harmful algal blooms	Turbidity, flow rate, and predator abundance	Prey abundance, flow rates, temperature, salinity, turbidity, contaminant loads
PRINCIPALLY MODIFIED BY...							
FLOW AFFECTS...	Prey abundance which can affect female size	Amount of spawning habitat available for species that spawn in the Bay watershed's rivers and in the estuary by modifying temperature, salinity, and other environmental conditions	Prey production and distribution throughout the Bay by influencing nutrient, and food transport, contaminant concentrations, and disease spread; ocean conditions affect abundance of certain prey species that enter the Bay	Residence time and fish distribution	Conditions that promote harmful algal blooms and dilutes concentrations of other contaminants	Transport of small fish and turbidity (cloudiness) of water, which hide small fish and reduce predation rates	Salinity, turbidity, flow rates, and prey availability that affect rearing success. Ocean conditions (such as upwelling) influence rearing success for some species in the lower Estuary

FRESHWATER FLOW DRIVES MULTIPLE MECHANISMS THAT AFFECT PRODUCTION OF FISH IN THE BAY

Figure 14: A generalized view of factors driving population fluctuations for many of the fish populations that depend on the Bay to complete their life cycle. The forces that produce each ecological feature and their impact on different fish species are too numerous to list; the key point is that freshwater flows into the estuary affect each of these drivers. The strength of the influence of freshwater flow or ocean impacts varies by species and by location of the life-history stage in question.

Ocean Impacts

Freshwater Impacts

SPATIAL DISTRIBUTION: THE ADVANTAGES OF SPREADING OUT IN THE LANDSCAPE

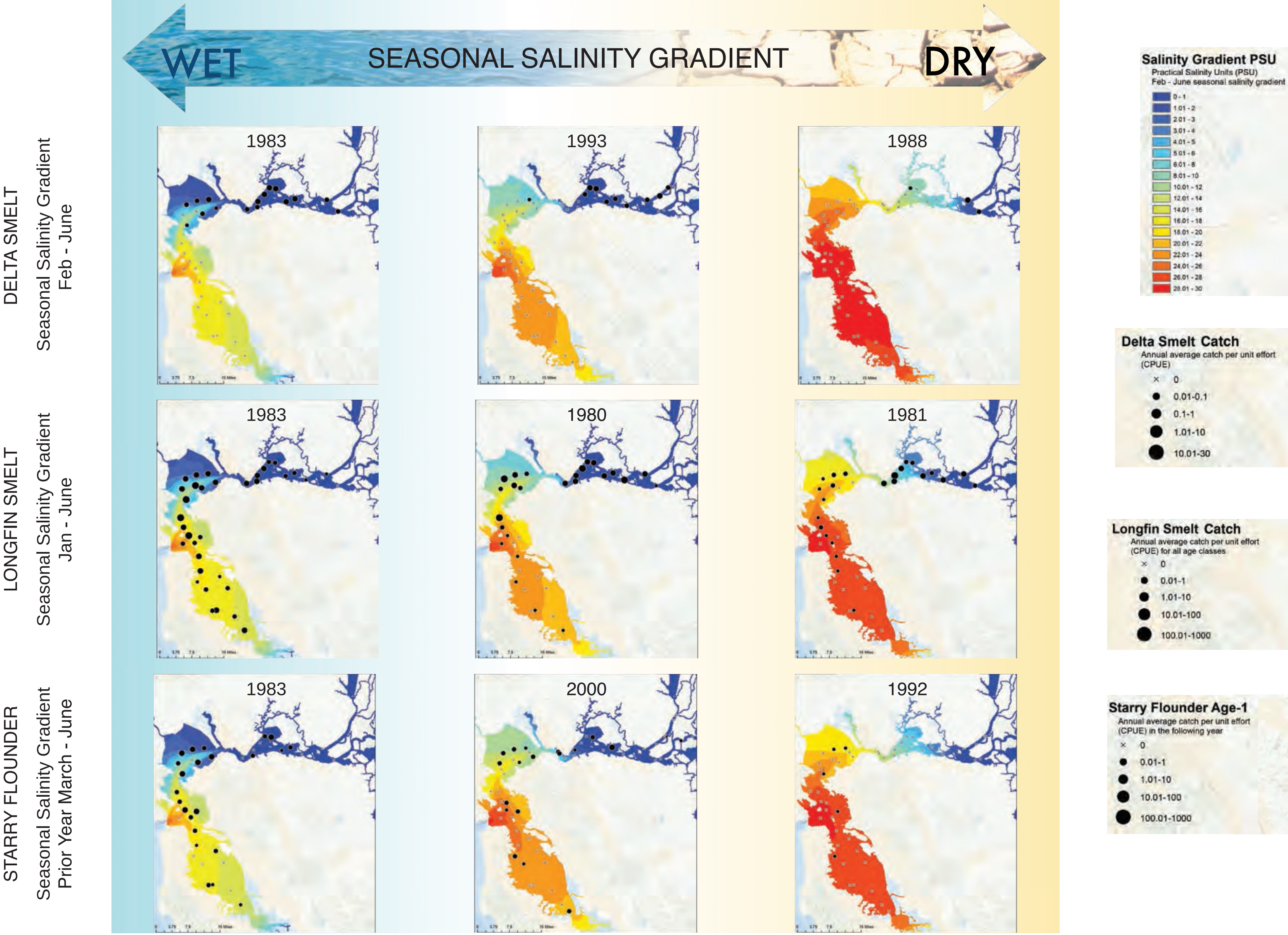
Populations are less vulnerable to extinction risk from both degraded local conditions and catastrophic events when they are more widely distributed in the landscape[125]. How much freshwater flow makes it downstream has a profound effect on how much habitat of different types is created and where it is located throughout the landscape of the estuary, in turn affecting where particular species can be found and how many individuals of that species can utilize a particular habitat (Figure 15). Because many native aquatic organisms in the Bay estuary have evolved to exploit its unique brackish water habitats, resident species such as Delta smelt and longfin smelt are typically associated with a narrow band of habitat in the Low Salinity Zone. When inflow to the estuary is reduced, the LSZ contracts in response, shrinking available habitat for the smelt and related species[126]. As the band of usable LSZ habitat contracts, it also moves upstream, shifting the distribution of longfin and Delta smelt upstream towards the Delta and increasing the number of fish that are lost to the giant south Delta pumps run by the federal Central Valley Project and State Water Project[127].

Adequate distribution isn't just a problem for resident fish. Flows can be so low in reaches of the southern Delta and the San Joaquin River basin that their use as migratory corridors by Chinook salmon and other species is impaired or eliminated[128], and water quality becomes so degraded that fish passage is blocked[129]. The inability to sustain the distribution of Chinook and other salmonids in the San Joaquin Valley portion of the Bay's watershed is highly problematic as a result of reduced freshwater flows[130]. In effect, this loss of spatial distribution makes all of the estuary's salmonid populations dependent on conditions in the Sacramento River valley; any problems there (e.g., a spill of toxic chemicals, disease outbreaks) could eliminate the Central Valley's production of salmonids.

Figure 15: The spatial distribution of many species changes in response to variation in freshwater inputs to the estuary. These maps show the distribution of three fish species across a range of Bay inflows and salinity gradients during the spring. For example, in an extremely wet year (like 1983) the distribution of Delta smelt (top row) extends throughout the upper estuary during the spring. In contrast, distribution of this native fish is limited to Suisun Bay and the Delta when the combined effect of drier conditions and high diversion levels makes Bay inflows extremely low, such as 1988. Starry flounder (bottom row) prefer habitats with intermediate salinities that are broadly available under high flow conditions, but less widespread when conditions are very dry. The wettest year (1983) is depicted for each species on the left hand side of the figure; drier years are shown to the right hand side. In the absence of water diversions or exports, salinity conditions similar to those depicted on the left would have occurred in 10 years between 1975-2014, but they actually occurred in only 4 of those years. By contrast, Super Critically Dry years only occurred naturally in one year (1977) during this four decade period, but similarly extreme conditions in the estuary actually occurred for 19 years – almost half the time.

Data sources: U.S. Environmental Protection Agency; California Department of Fish and Wildlife and the Interagency Ecological Program San Francisco Bay Study; Delta Modeling Associates (Salinity Gradient, Coarse-grid version of UnTRIM San Francisco Bay-Delta Model); and ESRI, DeLorme, BEBCO, NAANGDC, & other contributors (Basemap).

FISH DISTRIBUTION CHANGES IN RESPONSE TO THE SALINITY FIELD



FORAGE FISH – WHEN THE FOOD WEB IS THE SUM OF ITS PARTS

Collectively, small fish and large invertebrates that swim in open water are known as “forage fish.” They represent the prey base for larger fish, sea birds, and marine mammals, which often do not distinguish one kind of fish from another. Declines in forage fish populations are a known threat to populations of seabirds[131] and marine mammals[132]. Because of their crucial function in estuarine and marine food webs, global declines in forage fish have become a concern for scientists, ecosystem managers, and some fishing communities.

The populations of many forage fish species that were historically the most abundant in the estuary, such as longfin smelt, striped bass, American shad, Bay shrimp, and mysid shrimp, have declined dramatically in recent decades. Unlike many other areas of the world where they are overfished, forage fisheries are generally well managed in the Bay and nearshore coastal waters of California. Instead, these population declines are directly related to the long-term trend of reducing Bay inflow – indeed, a reliance on freshwater flow is the only thing some of these forage fish have in common (Figure 9). Forage fish have an ecological value much greater than their physical size. Without sufficient Bay inflow to provide the habitat conditions that allow forage fish populations to thrive, populations of other fish, birds, and marine mammals that rely on forage fish in the Bay and the Gulf of the Farallones are at risk of collapsing too.

Great Egret, one of many native bird species that relies on the fish and invertebrates produced by the San Francisco Bay foodweb. The effects of freshwater flow rates extend throughout the Bay ecosystem and beyond. Photo credit: David Sanger

FLOW IS FOR THE BIRDS, TOO

Fish, invertebrates, and other aquatic plants and animals aren’t the only creatures that benefit from Bay inflows, and suffer when they are reduced. The Bay estuary is also home to a diverse community of both resident and migratory birds. A critical part of the Pacific Flyway, the estuary provides crucial habitat for millions of migrating waterfowl and shorebirds, representing over 200 species. However, many bird populations that use the estuary are declining, and currently twenty-two bird species are listed as threatened, endangered, or species of special concern in this estuary[133].

It takes a fishery to support an aviary: Many factors are to blame for declines in bird populations, including urbanization, contaminants, and direct habitat loss. But long-term reductions in freshwater flows to the estuary likely contribute significantly to the pressure on the Bay's waterbird populations because of the resulting decline in the abundance of forage fish and the degradation of wetland habitat and water quality. Protecting fish-eating birds, such as pelicans, terns, and cormorants, requires production of a sufficient forage fish prey base. But populations of many fish species that depend on adequate inflows to the estuary have dropped well below the levels that are needed to maintain viable populations of pelagic seabirds[134].

Throughout the estuary many bird species are closely associated with wetland marshes[135], and large areas of the upper estuary, especially in Suisun Marsh, are managed to provide fresh and slightly brackish habitat for ducks. As reducing inflows makes the estuary more saline over time, the diversity and composition of wetland vegetation will change as well, affecting its habitat value for bird species. Salinity-induced wetland vegetation shifts in recent years have been as extreme as experienced in the most severe natural drought periods in California's history[136]. Changing salinities can limit the diversity of seeds stored in the soil and the productivity, diversity, and composition of wetlands[137]. Animal species that depend on these marshes are likely also impacted by salinity and vegetation changes resulting from reduced inflow[138]. Finally, impaired water quality that is exacerbated or caused by low inflows also harms the Bay's many bird populations.

DRIVING RECREATIONAL AND COMMERCIAL FISHERIES INTO THE ABYSS?

It would be a sadder and poorer world if Californians allow the San Francisco Bay estuary to become so impaired that its unique and wonderful aquatic life, and the birds and mammals that feed on it, disappears forever. But the consequences are not only ecological, or spiritual, or esthetic – there are extremely significant economic costs as well. The Bay Area has always been a major hub of the Pacific Coast's commercial fishing industry. Bay Area residents and tourists from across the globe come to San Francisco Bay in order to enjoy the pursuit of salmon, sturgeon, and many other game fish and, if they're lucky, to bring home a delicious dinner.

"Fish-friendly water management" is the only option: Today, Chinook salmon are one of the most recognizable and cherished fish on the Pacific Coast, and their production in the Bay's watershed supports a commercial and ocean recreational fishery that extends all the way from Monterey Bay to Oregon. But these valuable fisheries are extremely vulnerable to changes in Bay inflows. The long-term trend of flow alteration (combined with habitat degradation and poor hatchery management) in the watershed, and the associated declines in salmon production, has been a contributing factor to the loss of thousands of jobs and the beaching of hundreds of boats in the fishing industry[139]. When these long-term problems overlapped with poor ocean conditions, fishing for Chinook salmon off the California coast was closed completely in 2008 and 2009 (and through most of 2010). At the time, much attention was focused on the role of ocean conditions (and their relationship to global climate change); however, the most comprehensive scientific study of the unprecedented closure of the fishery noted that decades of poor habitat conditions in their freshwater nurseries

San Francisco Bay is home to both commercial and recreational fisheries such as Pacific herring pictured in this photo. Fisheries for many species like salmon and starry flounder depend on the health of the Bay ecosystem, including numerous ecological processes that are driven by freshwater flows to the estuary. Photo Credit: David Sanger had set the stage for this collapse and called for "…more fish-friendly water management…" as one of the few actions that might prevent the problem from recurring[140]. If California wants to preserve its salmon fisheries, the only effective antidote for poor ocean conditions is to improve flow conditions upstream of the Golden Gate.

It's not just salmon on the plate: The Bay supports many other important fisheries, including the nation's last major urban commercial fishery (for Pacific herring). For instance, there is a valuable sport and recreational fishery for starry flounder, a predatory fish, which once produced hundreds of metric tons in California[141]. The flounder population in the estuary grows or contracts depending on how much water flows into the Bay during the spring[142]. In addition, tourists and Bay Area residents pay substantial amounts of money (for tackle, licenses, and a boat ride) to try to catch white sturgeon in the Bay; the spawning success of these giant fish is directly related to flow from the watershed into the estuary[143]. Sacramento splittail, an endemic species that depends on periodic flooding to inundate its spawning habitats, are also a staple of recreational and subsistence fishing in the upstream portions of the estuary. Invertebrates, like oysters and Dungeness crab, are also much sought after, and again maintenance and restoration of their habitats and populations requires more careful management of freshwater flows to the Bay. Unless flow conditions are improved, these fisheries could all go the way of the once vibrant fisheries for Delta smelt and longfin, two species that were once ubiquitous in the estuary but are now so rare that they are listed as endangered. As these fisheries disappear, the fishing communities that depend on them – from small towns along the coast to families who rely on subsistence fishing in the Delta to the seafood-related businesses of Fisherman's Wharf – are at risk as well.

MARINE MAMMALS SUFFER WHEN REDUCING FLOWS REDUCES THEIR FOOD SUPPLY

There are few more amazing and thrilling experiences for Bay Area residents and visitors than to observe sea lions and seals hauling up onto local docks and piers, or to take a whale-watching trip to see the Orca whales (the "Southern Resident killer whale" population) that feed and migrate right outside the Golden Gate. These protected marine mammal species eat fish and other organisms that rely on the estuary and its Central Valley watershed as spawning and rearing grounds. By diminishing the estuary's productivity and changing its food web, reducing Bay inflows can produce cascading effects that eventually create problems for local marine mammal populations. For example, the local Southern Resident killer whale population specializes in eating Chinook salmon; the abundance, reproductive success, and mortality rates of resident Orcas are linked to prey limitation caused by recent Chinook salmon declines[144]. Orca whales have come to rely on Chinook salmon because they are large fish with a high fat content that were historically abundant throughout the year, so the decline of salmon stocks has had dire consequences for resident Orcas. Dwindling supplies of salmon are believed to restrict the recovery of the local population[145]. As a result of mismanaging flows in the estuary and its watershed, the future of these two iconic species in the Bay Area is uncertain.

CASCADING EFFECTS OF FRESHWATER FLOW IN THE SAN FRANCISCO BAY ESTUARY

	NEARSHORE OCEAN	SAN PABLO, CENTRAL, AND SOUTH BAYS	SUISUN BAY AND MARSH	DELTA
PROCESSES AFFECTED BY FRESHWATER FLOWS	• Sediment transport (turbidity) • Nutrient transport • Beach formation	• Sediment transport (turbidity) • Nutrient transport • Marsh accretion • Changes in the availability of habitats with different salinities • Water column stratification	• Sediment transport (turbidity) • Nutrient transport • Marsh accretion • Changes in the availability and location of habitats with different salinities • Residence time • Food web productivity • Gravitational circulation, fish and wildlife migrations	• Sediment transport (turbidity) • Nutrient transport • Marsh accretion • Residence time • Floodplain innundation • Fish and wildlife migrations • Contaminant loading • Toxic algal production • Keep brackish water "at bay", maintains agricultural and drinking water quality
BIOLOGICAL EFFECTS ASSOCIATED WITH FRESHWATER FLOWS	• Increase food web productivity • Improve survival and fitness of resident Orca whales and other marine mammal populations • Create/maintain/improve beach habitats • Increase fishery productivity	• Control wetland plant species composition and distribution • Improve abundance and distribution of many native species including those that become food for other species • Increase fishery productivity • Create/maintain/improve brackish marsh habitat	• Improve abundance and distribution of many native species, including those that become food for other species • Increase fishery productivity • Create/maintain/improve brackish marsh habitat	• Prevent harmful algal blooms • Improve abundance and distribution of many native species • Increase fishery productivity • Control spread of invasive species • Reduce entrainment of endangered fish at Delta export pumps

FRESHWATER FLOWS

Figure 16: Most fresh water comes to San Francisco Bay from rivers of the Central Valley's watershed, via the Sacramento-San Joaquin Delta (upper right). The effects of flowing fresh water (including the transport of food, nutrients, sediments, and organisms produced upstream) can be felt throughout San Francisco Bay and into the nearshore Pacific Ocean. Along the journey from the rivers to the ocean, freshwater flows affect numerous processes and habitats, generating a variety of biological outcomes. Generally speaking, managing water diversions upstream of the Bay in a more sustainable manner will lead to higher flow rates, more natural variability in those flow rates, and increasing benefits for the larger San Francisco Bay ecosystem and the people who live in and visit the Bay Area.

PEOPLE ARE THE ULTIMATE LOSERS FROM LOW BAY INFLOWS

Clearly, people benefit from a healthy San Francisco Bay in many ways (Figure 16). When the Bay's fish and wildlife populations are thriving, they provide enormous commercial and recreational opportunities, from taking your family to discover the unique plants and animals of the Bay's wetlands and beaches to going whale watching or salmon fishing, and they feed millions of people each year. Collectively, the Bay's natural resources make San Francisco one of the most attractive places in the world to live and visit.

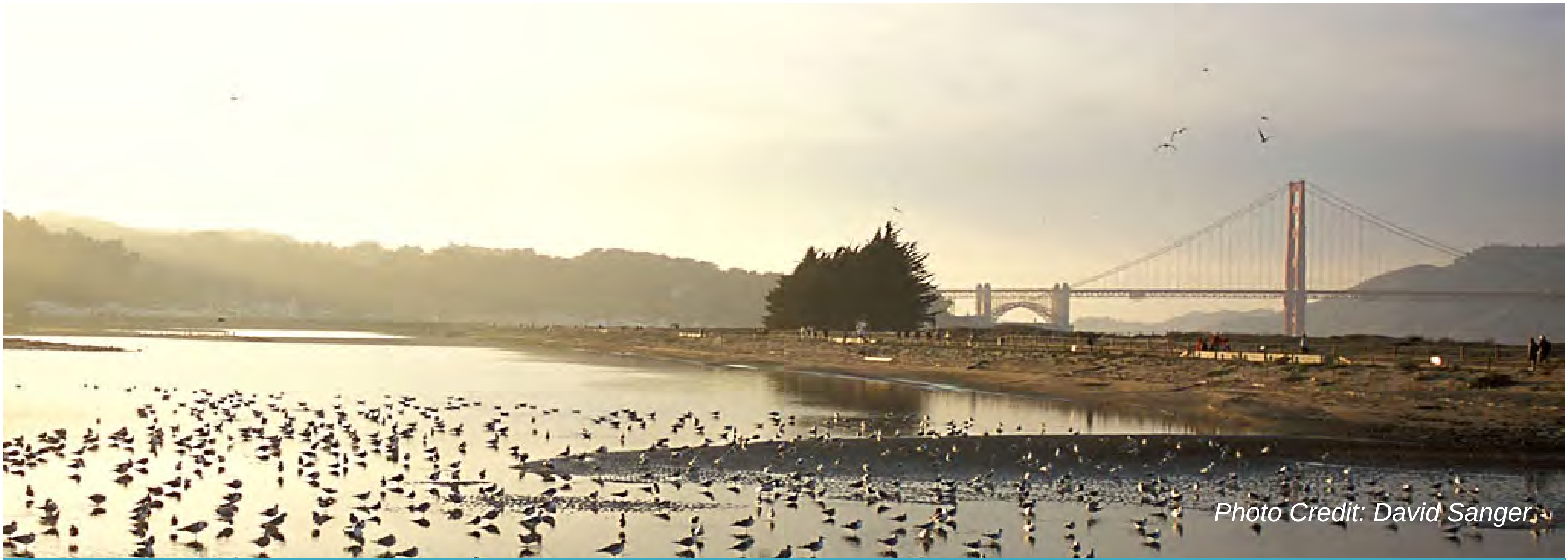
People don't just benefit from observing wildlife and eating seafood, but regularly enjoy direct contact with the Bay. Many "play in the Bay" when they wade, swim, sail, or kayak in its waters; these activities are only enjoyable when the Bay's waters are clean and there are wetlands and beaches to visit. When Bay inflows decline, water quality and the ability to resupply beaches and wetlands with sediment declines as well.

Don't go near the water without a hazmat suit: We now know that low inputs of Bay inflow not only degrade water quality but also are beginning to cause periodic harmful algae blooms in the estuary. These harmful "algae" (actually, cyanobacteria) produce neurotoxins powerful enough to make humans sick and even to kill dogs, otters, and other small mammals[146]. The Microcystis cyanobacteria blooms more frequently when low fresh water flows reduce flushing and decrease turbidity in the Delta[147]. Although this species blooms only in the fresh water of the upper estuary, its toxin can be transported downstream; in fact, the neurotoxin was recently detected in invertebrates in the saltier waters of the Central Bay[148]. Thus, the problem of low Bay inflow not only harms fish and wildlife but also threatens water quality and recreational opportunities for people throughout the larger Bay Area. This alarming development has the potential to reverse the positive effects of our decades old, multi-billion dollar investment in cleaning up the Bay's waters.

The reduction of Bay inflows also poses a threat to the continued existence of the beaches and wetlands that surround the Bay and the coastal areas nearby the Golden Gate, popular recreational sites that attract both residents and tourists throughout the year. These special environments rely on a continuous supply of sediments to maintain themselves in the face of ongoing erosion from storm runoff and waves. Delivery of sediments to the Bay and coastal environments, and our ability to maintain these important features, is controlled in part by how much freshwater inflow we allow to reach the estuary. As Bay inflows are constricted by human water diversions, they mobilize less sediment; many of the Bay Area's beaches and wetlands are rapidly eroding for lack of sediment resupply. As sea levels rise, the resupply problem will become even more critical.

A Bay Area where it's hard to catch salmon, see pelicans or Orca whales, find a bowl of cioppino made with today's local catch, hang out at the beach, or even be in contact with the water? This is a high price to pay for tolerating California's unsustainable approach to managing its aquatic resources, where so little freshwater flow is allowed to make the life-giving journey to San Francisco Bay and the Golden Gate.

The time is now for Californians to decide whether we really want to pay that price – or the choice will be made for us; the loss of the many ecosystem services and economic benefits the Bay still provides today will become just another cautionary tale to pass on to future generations.



TURNING THE FLOW BACK ON

WHAT CAN BE DONE TO REVIVE THE FRESHWATER-STARVED ESTUARY?

Fortunately, there's still time to avoid the increasingly likely scenario where native fish species go extinct; toxic algal blooms become common; recreational and commercial fisheries are permanently closed; marshes erode, grow more saline and less diverse; and the Bay Area's tourism and recreational portfolio loses value.

To avoid that scenario, Californians must choose a different pathway for how we manage flows and water supplies in the future. As mentioned in the beginning of this report, while most of the outcomes of water management conflicts are experienced downstream in the Bay, most of the causes – and the solutions –

manifest themselves in the Bay's watershed. Here are some of the essential elements of a watershed-wide solution pathway.

ADOPT STRONGER WATER QUALITY STANDARDS FOR THE BAY ESTUARY NOW, AND UPDATE THEM BASED ON WHETHER ECOLOGICAL TARGETS ARE BEING MET

The federal Clean Water Act requires the states to adopt, and obtain federal approval of, standards that fully protect designated beneficial uses of water, and then to review them every three years to ensure they are achieving their purpose. California last updated water quality standards for the Bay estuary, over 20 years ago, in 1995. In this estuary, the beneficial uses of water most sensitive to human alteration and degradation and most at risk of being extinguished are related to fish and wildlife, including estuarine habitat, fish migration, and coldwater habitat. Many policy-makers, regulators, and independent scientific reviewers have concluded over the last decade that the freshwater flows required by the 1995 standards are not sufficient to protect fish and wildlife beneficial uses of the estuary. For example, the Governor's Delta Vision Task Force, the California State Water Resources Control Board, the California Department of Fish and Wildlife, the National Research Council, and the U.S. Environmental Protection Agency[149] have all made such findings. The promulgation of new, more protective flow standards by the Water Board and the EPA that require substantially more inflow to San Francisco Bay is the single most pressing item on the agenda for saving the estuary. Delays in completing the update, begun in 2009, must come to an end, and new standards updated in short order.

A wealth of scientific evidence supports increasing required flows to save native fish and wildlife populations and restore productivity of the estuarine. But the record also indicates that increased flows and flow variability help control the spread or damage caused by invasive species that have colonized the estuary, and suggests that they might control new invasions as well. Federal and state regulators should consider developing and adopting additional flow requirements that are specifically designed to provide conditions that inhibit the establishment and spread of invasive species.

Get SMART: The new standards for flow (and other water quality parameters) should not only be fully protective of the most sensitive fish and wildlife beneficial uses, but also be linked to a set of biological performance measures that define the desired outcomes for fish and wildlife beneficial uses using SMART (specific, measurable, achievable, relevant, and time-bound) objectives[150]. These SMART objectives should include targets for population viability of key species (i.e., abundance, diversity, productivity, and distribution, as discussed in the previous chapter) and targets for ecological conditions associated with population response (e.g., temperature or habitat availability). Although the Clean Water Act requires triennial review of standards, most standards are not updated more often than once in a generation, and the process is usually politically controversial. Measuring progress toward achieving SMART biological objectives can allow regulators to adjust flows and other environmental safeguards, within a narrow pre-determined range, to achieve better, more timely protection of fish and wildlife uses of the estuary. This adaptive management approach also lends itself to efforts to improve our understanding of the flow regimes, including magnitude, duration, seasonality, and frequency of flows, that will effectively suppress invasive species.

REQUIRE ALL WATER DIVERTERS TO CONTRIBUTE THEIR FAIR SHARE

Currently, the federal Central Valley Project and the State Water Project are assigned the primary responsibility for releasing water from their reservoirs to achieve the flow and water quality standards for the Bay estuary. Strictly speaking, this first and foremost affects the contractors served by the projects, who have water rights that are junior to others in the watershed. The strange reality is that irrigation districts and cities with senior rights, including those parties who exchanged their senior water rights for delivery contracts with the projects, are not directly required by regulators to help attain water quality standards set for the Bay and Delta. This leaves a subset of water users, representing a quarter or less of total diversions, as the parties primarily responsible for meeting water quality standards for the entire estuary[151]. Updated water quality standards that require all water users, including senior water rights holders, to contribute a fair share of the total flow needed to meet standards that are designed to stablize and restore the estuarine ecosystem could generate millions of acre-feet of additional freshwater flows to the Bay Estuary; spreading the obligation among a larger group of water diverters would reduce inequities in current water allocations, as well. Everyone should be responsible for protecting public resources before anyone receives the public's water to use for their own private gain. Any pathway that fails to set and integrate the obligations of this larger subset of water users will not generate sufficient flow to solve the estuary's problems.

More broadly, California's archaic water rights system needs to be modified to reflect the realities of twenty-first century society, law and climate. Not only are different water users treated differently based on priority in time rather than urgency of need, but the state's water resources are wildly over-allocated as a result of historically awarding the right to use water without examining whether adequate supplies exist. Total water rights allocations in California equal five times California's mean annual runoff, and water rights in major river systems in the Bay's watershed account for up to 1000% of natural supply[152]. As long as water rights are so over-allocated, there will always be pressure to withdraw more water from the Bay's watershed than is sustainable in the long term, and corresponding political pressure to weaken water quality standards or other flow-related environmental protections. In the past, water rights reform and groundwater management were both considered third rails in California politics; now the first phases of groundwater reform have become a reality, but not before over-exploitation of these resources caused some communities to run out of water and the earth's surface to subside. The time to consider updating our water rights system has also come; reform needs to happen before the even more awful to contemplate impacts of over-allocation become irreversible.

REDUCE RELIANCE ON THE DELTA AS A SOURCE OF WATER SUPPLY

The upper estuary is ground zero in the battle over how water is managed – and mismanaged – in California, and it is here that the magnitude of the effects of unsustainable water diversions on fish, wildlife, habitat, and ecological processes are most apparent. In 2009 the California Legislature recognized the vulnerability of the upper estuary and the need to reduce human pressure on this ecosystem by passing the Sacramento – San Joaquin Delta Reform Act, which among other things set a new state policy:

> … to reduce reliance on the Delta in meeting California's future water supply needs through a statewide strategy of investing in improved regional supplies, conservation, and water use efficiency. Each region that depends on water from the Delta watershed shall improve its regional self-reliance for water through investment in water use efficiency, water recycling, advanced water technologies, local and regional water supply projects, and improved regional coordination of local and regional water supply efforts.[153]

Regional self-reliance in areas now exporting water from the Bay's watershed means using less water to provide the same goods and services (e.g., through water efficiency, conservation, leak reduction); using water more than once before disposing of it (water recycling); cleaning up degraded water so that it can be used for productive purposes (brackish water reclamation); using local runoff for nonpotable water use (stormwater capture and reuse); and storing water underground in groundwater aquifers during wet years (conjunctive use, water banking, stormwater recharge). According to a 2014 review by the Pacific Institute and the Natural Resources Defense Council, up to 14 million acre-feet of water per year – over half the total amount of water used for human use throughout the Bay's watershed each year – could be saved from combined investments in these strategies[154].

These approaches can also reduce the carbon footprint of water management and respond to shifts in hydrology caused by climate change. Increasing local self-reliance avoids expending the energy needed to transport imported water long distances from its source. For instance, transporting water via the State Water Project represents about 3% of the state's total energy consumption[155]. Using the natural capacity of groundwater basins to clean and store storm runoff for later use reduces much of the energy and expense associated with capturing, treating, and disposing of stormwater. Expanding that capacity by enlarging flood basins and floodways and reoperating existing reservoirs can temporarily capture more of the larger floods that will be typical of a warming climate, and then divert these flows to groundwater recharge areas.

Town and country together: Regional self-reliance also requires that the inequities between urban and agricultural water uses be addressed. Urban water users generally pay a much higher cost for water, invest more in conservation and other demand management strategies, and are held to a higher standard for using water efficiently (e.g., the state's mandated target of reducing per capita water use in the urban sector by 20% vs. the absence of any quantitative target for reducing use in the irrigation sector). Targets for saving water and becoming locally self-reliant should be set as appropriate for each economic sector and each region of the state; permitting and funding decisions by local, state and federal agencies should be linked to performance in meeting these targets.

INTEGRATE FLOW AND HABITAT RESTORATION TO BATTLE CLIMATE CHANGE

The decline of sediment inputs from reducing Bay inflows has contributed to the erosion of marshlands and beaches throughout the Bay estuary and nearby coastal areas. That problem is now greatly magnified by the effect of climate change on sea levels. Rising sea levels are a challenge to the continued existence and quality of the Bay estuary's marshes and to life and property for human communities along the shoreline of the Bay and coastal areas. Significant efforts have been underway for decades to acquire and restore wetland areas around the estuary; more recently, there is serious interest in innovative approaches like combining marsh restoration with construction of earthen levees in order to establish a low-cost and effective regional network of flood barriers[156]. Providing for a more natural pattern of higher winter and spring inflows to the Bay will increase sediment resupply to restored marshes and "horizontal levees," helping maintain them long after the initial construction effort. Restored freshwater and brackish marshes also need enough freshwater inflows at the right times of year to maintain their species composition and diversity. Marsh restoration and flood protection efforts, as well as beach rehabilitations, should consider flow regime requirements during design and evaluation of projects, and as part of the permitting process where appropriate.

Wetlands Photo Credit: David Sanger

WE MUST ACT NOW

The science overwhelmingly indicates that more freshwater flow, following a more natural pattern, must reach the San Francisco Bay estuary to restore its fish, wildlife, water quality, food web, marshes, beaches, coastal fisheries, and other public benefits. The only barriers to action are the general lack of understanding about the severely degraded condition of this freshwater flow-starved estuary and the lack of political will to change the unsustainable way California manages its water resources. Can Californians be made aware of the pending collapse of the Bay estuary ecosystem – and the loss of all which that ecosystem provides us – and motivated to demand action now? Can decision-makers at every level – federal, state, and local – be prevailed upon to take the steps necessary to prevent the destruction of California's greatest aquatic ecosystems before it is too late? The window of opportunity to protect this treasure is closing rapidly.

ENDNOTES

[1] Conomos 1979; McKee et al. 2013; Barnard et al. 2013a; SFEP 2015

[2] TBI 1998

[3] Ibid.

[4] Stine 1994, 1996; Austin 2015

[5] TBI 1998

[6] SWRCB 2010

[7] Richter et al. 2011

[8] Florsheim and Dettinger 2015; SFEP 2015

[9] Knowles 2002

[10] Odum 1970; SFEP 2015

[11] Jassby et al. 1995; Kimmerer 2002 a,b

[12] USFWS 1995; Dege and Brown 2004; Grimaldo et al. 2009

[13] Feyrer et al. 2007, 2010; Sommer et al. 2011; IEP 2015

[14] Kimmerer 2002 a,b

[15] Cloern and Jassby 2012; SFEP 2015

[16] Nichols et al. 1990, Alpine and Cloern 1992

[17] Winder et al. 2011

[18] Majardja et al. 2015

[19] Lyons et al. 2005; Callaway et al. 2007

[20] TBI 1998

[21] Malamud-Roam and Ingram 2003; Malamud-Roam and Ingram 2004

[22] Byrne et al. 2001

[23] Sanderson et al. 2000; Stralberg et al. 2011

[24] Callaway et al. 2007

[25] Takekawa et al. 2006; Parker et al. 2011; Stralberg et al. 2011

[26] Callaway et al. 2007

[27] Goals Project 2015

[28] Peterson et al. 1996

[29] Stahle et al. 2001

[30] Chang et al. 2014

[31] Cloern 1983; Conomos et al. 1979

[32] Pearson 1989

[33] Hurst and Bruland 2008

[34] Largier et al. 2011

[35] Peterson et al. 1994

[36] Fox et al. 1991

[37] TBI 1998

[38] Cloern et al. 2012

[39] Largier 1996

[40] Feyrer et al. 2015

[41] NOAA 2015

[42] McKee et al. 2002

[43] PWA 2002 as cited in McKee et al. 2002

[44] Schoellhamer 2009

[45] Kondolf, 2000; McGrath 2001 pers comm as cited in McKee et al. 2002; SFEP 2015

[46] Schoellhamer et al. 2013; SFEP 2015

[47] Wright and Schoellhamer 2004

[48] Barnard et al. 2013a

[49] Wright & Schoellhamer 2004; Cloern et al. 2011

[50] IEP MAST 2015; Gregory 1993; Gregory and Levings 1998

[51] Baskerville-Bridges 2004, Feyrer et al. 2007, Nobriga et al. 2008, Grimaldo et al. 2009, Sommer and Mejia 2013; Thompson et al. 2010

[52] Nyman et al. 1990, Callaway et al. 2007

[53] Stralberg et al. 2011

[54] TBI 2013

[55] Goals Project 1999

[56] Barnard et al. 2013a

[57] Porterfield 1980

[58] Barnard et al. 2013b and 2013c

[59] Tobias 2014

[60] Nichols & Pamatmat 1988

[61] Nichols et al. 1986

[62] SFEI 2015

[63] Leatherbarrow et al. 2004

[64] Luoma and Presser 2009.

[65] Stewart 2013

[66] Okamoto 2014

[67] Ibid.

[68] Malbrouck and Kestemont 2006; Miller et al. 2010

[69] Lehman et al. 2005; Berg and Sutula 2015

[70] Lehman et al. 2010; UC Santa Cruz 2015

[71] Berg and Sutula 2015

[72] Sanderson et al. 2000; Stralberg et al. 2011; Callaway et al. 2007

[73] Lyons et al. 2005, Callaway et al. 2007

[74] Feyrer et al. 2015; Arthington 2012; SFEP 2015

[75] Robins et al. 2006

[76] Williams 2006; Cunningham et al. 2015

[77] NMFS 2009

[78] Jassby et al. 1995; Kimmerer 2002a

[79] Baxter et al. 1999; Kimmerer 2002a

[80] Jassby et al. 2002

[81] Jassby and Cloern 2000 cited in Jassby 2008

[82] Nichols et al. 1986, Cloern and Jassby 2012

[83] Winder et al. 2011 and sources cited therein

[84] SOTER 2015

[85] Jassby et al. 2002

[86] Winder and Jassby 2010, Winder et al. 2011, Cloern and Jassby 2012

[87] e.g., Kratville 2008; Nobriga and Rosenfield 2015.

[88] Peterson and Vassieriers 2010

[89] Nichols et al. 1990, Winder et al. 2011

[90] Moyle 2008, Berg and Sutula 2015; Mahardja et al. 2015

[91] Lehman et al. 2010

[92] Walters et al. 1985

[93] Cloern 1996; Conomos et al. 1979

[94] Conomos et al. 1979

[95] Monismith, et al. 1996; Cloern 1996

[96] Cloern et al. 1984; Cloern et al. 1989

[97] Cloern 1996

[98] Hurst and Bruland 2008

[99] Bunn and Arthington 2002; Poff and Zimmerman 2010; Pearson 1989; CDFG 1992; Jassby et al. 1995; Baxter et al. 1999; Kimmerer 2002a; Monismith et al. 2002; Rosenfield and Baxter 2007; Sommer et al. 2007; Kimmerer et al. 2009; Feyrer et al. 2015

[100] SWRCB 2010; CDFG 2010; NRC 2010

[101] Stevens and Miller 1983; Jassby et al. 1995; Kimmerer 2002a, b; Mac Nally et al. 2010; Thomson et al. 2010

[102] Michel et al. 2015

[103] Rosenfield and Baxter 2007

[104] Nobriga and Rosenfield 2016

[105] Hughes et al. 2014

[106] Kimmerer 2002a

[107] Jassby et al. 1995; Kimmerer 2002a

[108] Baxter et al. 2010; Kimmerer 2002a; Jassby et al. 1995

[109] Pearson 1989

[110] Feyrer et al. 2010

[111] Jassby and Van Nieuwenhuyse 2005

[112] Healy 1991; Quinn 2005; Marston et al. 2012

[113] TBI 2012

[114] Kimmerer 2008; Cunningham et al. 2015

[115] Nichols et al. 1990; Peterson and Vassieriers 2010; Mahardja et al. 2015

[116] Bennett 2005; J. Hobbs, U.C. Davis, personal communication, December 3, 2009

[117] Bennett 2005; Fisch et al. 2011

[118] Hilborn et al. 2003; Satterthwaite et al. 2014; Sturrock et al. 2015

[119] Lindley et al 2009

[120] TBI et al. 2010

[121] Feyrer et al. 2015

[122] Nobriga and Rosenfield 2015; Sturrock et al 2015; Stevens and Miller 1983

[123] Kimmerer 2006

[124] Kimmerer 2002a; T. Grenier pers. Comm. 2014

[125] e.g., Macarthur and Wilson 1967; Rosenfield 2002

[126] Kimmerer et al. 2009; Feyrer et al. 2007, 2010

[127] Grimaldo et al. 2009

[128] Marston et al. 2012

[129] Jassby and van Nieuwenhuyse 2005

[130] SWRCB 2010; CDFG 2010

[131] Cury et al. 2011

[132] Ford and Ellis 2006; Ford et al. 2010; Ward et al. 2009

[133] Audubon California 2016

[134] Cury et al. 2011

[135] Takekawa et al. 2006

[136] Byrne et al. 2001

[137] Jin 2008; Parker et al. 2011

[138] Takekawa et al. 2006

[139] e.g., American Sportfishing Association 2009 and PFMC 2015

[140] Lindley et al. 2009

[141] Ralston 2005

[142] Kimmerer 2002a

[143] Kohlhorst 1991; Israel et al. 2009

[144] Ford and Ellis 2006; Ford et al. 2010; Ward et al. 2009

[145] Ford et al. 2010

[146] Miller et al. 2010

[147] Berg and Sutula 2015

[148] UC Santa Cruz 2015

[149] Governor's Delta Vision Blue Ribbon Task Force, 2008; SWRCB 2010; NRC 2010; USEPA 2012

[150] TBI et al 2010, exhibit 1; SEP Group 2015, unpublished

[151] DWR 2013a; USBR 2012; USBR 2016

[152] Grantham and Viers 2014

[153] California Water Code Section 85021

[154] Pacific Institute and NRDC 2014

[155] CDWR 2013b

[156] ESA/PWA 2013

REFERENCES

Alpine, A. E., and J. E. Cloern. 1992. Trophic interactions and direct physical effects control phytoplankton biomass and production in an estuary Limnology and Oceanography 37:946-955.

American Sportfishing Association. 2009. Economic Data Supports Efforts to Recover California's Salmon Fisheries. Available at: http://asafishing.org/newsroom/news-releases/economic-data-supports-efforts-to-recover-californias-salmon-fisheries/

Arthington, A. H. 2012. Environmental Flows: Saving Rivers in the Third Millennium. UC Press.

Audubon California. 2016. Protecting bird habitat in the Bay-Delta region. Website: http://ca.audubon.org/protecting-bird-habitat-bay-delta-region

Austin, J. T. 2015. Floods and Droughts in the Tulare Lake Basin, 2nd edition. Sequoia Parks Conservancy, Three Rivers, California. (see also http://www.tulare-basinwatershed.org/latest-news/making-sense-water-tulare-basin)

Barnard, P.L., D.H. Schoellhamer, B. E. Jaffe, and L. J. McKee. 2013 (a). Sediment transport in the San Francisco Bay Coastal System: an overview. Marine Geology, Special Issue San Francisco Bay 345, 3–19

Barnard, P.L., L. H. Erikson, E. Elias, P. Dartnell. 2013 (b). Sediment transport patterns in the San Francisco Bay Coastal System from cross-validation of bedform asymmetry and modeled residual flux. Marine Geology, Special Issue San Francisco Bay 345, 74–97

Barnard, P.L., A. C. Foxgrover, E. P. L. Elias, L. H. Erikson, J. R. Hein, M. McGann, K. Mizell, R. J. Rosenbauer, P. W. Swarzenski, R. K. Takesue, F. L. Wong, and D. L. Woodrow. 2013 (c). Integration of bed characteristics, geochemical tracers, current measurements, and numerical modeling for assessing provenance of beach sand in the San Francisco Bay Coastal System. Marine Geology 345, 181–206

Baskerville-Bridges, B., J. C. Lindberg, and S. I. Doroshov. 2004. The effect of light intensity, alga concentration, and prey density on the feeding behavior of Delta smelt larvae. American Fisheries Society, Special Publication 39:219-228.

Baxter, R., R. Breuer, L. Brown, L. Conrad, F. Feyrer, S. Fong, K. Gehrts, L. Grimaldo, B. Herbold, P. Hrodey, A. Mueller-Solger, T. Sommer, and K. Souza. 2010. Pelagic Organism Decline Work Plan and Synthesis of Results. Interagency Ecological Program, Sacramento, CA.

Baxter, R., K. Hieb, S. DeLeon, K. Fleming, and J. Orsi. 1999. Report on the 1980-1995 Fish, Shrimp, and Crab Sampling in the San Francisco Estuary, California, Technical Report 63. Editor J. Orsi. California Department of Fish and Game, Stockton, CA, #3075994.

Bennett, W.A. 2005. Critical assessment of the Delta smelt population in the San Francisco Estuary, California. San Francisco Estuary and Watershed Science 3(2): [Article 1]. Available from: http://repositories.cdlib.org/jmie/sfews/vol3/iss2/art1

Berg, M., and M. Sutula. 2015. Factors affecting growth of cyanobacteria with special emphasis on the Sacramento-San Joaquin Delta. Southern California Coastal Water Research Project Technical Report No. 869. Prepared for: The Central Valley Regional Water Quality Control Board and The California Environmental Protection Agency State Water Resources Control Board (Agreement Number 12-135-250). Available at: http://ftp.sccwrp.org/pub/download/DOCUMENTS/TechnicalReports/869_FactorsAffectGrowthOfCyanobacteria-1.pdf

Bunn, S. E., and Arthington, A. H., 2002. Basic principles and ecological consequences of altered flow regimes for aquatic biodiversity. Environmental Management 30:492–507.

Byrne, R., B. L. Ingram, S. Starratt, F. Malamud-Roam, J. N. Collins, and M. E. Conrad. 2001. Carbon-isotope, diatom and pollen evidence for late Holocene salinity change in a brackish marsh in the San Francisco estuary. Quaternary Research 55:66–76.

California Department of Fish and Game (CDFG). 1992. Estuary Dependent Species. Exhibit WRINT-DFG-Exhibit # 6 entered by the California Department of Fish and Game for the State Water Resources Control Board 1992 Water Quality/Water Rights Proceedings on the San Francisco Bay/Sacramento – San Joaquin Delta.

California Department of Fish and Game (CDFG). 2010. Quantifiable Biological Objectives and Flow Criteriafor Aquatic and Terrestrial Species of Concern Dependent on the Delta. Report prepared pursuant to the Sacramento-San Joaquin Delta Reform Act of 2009.

California Department of Water Resources (DWR). 2013a. California Water Plan Update 2013: Investing in Innovation & Infrastructure. Bulletin 160-13.

California Department of Water Resources. 2013b. North-Of-The-Delta Offstream Storage Project EIR/EIS, Preliminary Administrative Draft (Chapter 31: Power, Production and Energy). Available at: http://www.water.ca.gov/storage/docs/NODOS%20Project%20Docs/NODOS_Prelim_Admin_Draft_EIR/31-Power_Energy_prelim_admin_draft_Dec2013_w_figures.pdf

California Water Code Section 85021

Callaway, J. C., V. T. Parker, M. C. Vasey, and L. M. Schile. 2007. Emerging issues for the restoration of tidal marsh ecosystems in the context of predicted climate change. Madroño 54(3):234–248.

Chang, A. L., A. K. Deck, P. D. Malm, K. Willits, S. Attoe, J. L. Fisher, and S. G. Morgan. 2014. Great place to live, but I wouldn't want to raise my kids there: Linking habitat quality and population dynamics of Olympia oysters in San Francisco Bay. State of the Estuary Conference 2014. Handout for poster?

Cloern, J. E. 1984. Temporal dynamics and ecological significance of salinity stratification in an estuary (South San Francisco Bay, USA). Oceanologica Acra 7,137-141.

Cloern, JE. 1996. Phytoplankton bloom dynamics in coastal ecosystems: a review with some general lessons from sustained investigation of San Francisco Bay, California. Reviews of Geophysics 34:127-168

Cloern, J. E., A. E. Alpine, B. E. Cole, R. L. Wong, J. F. Arthur, and M. D. Ball. 1983. River discharge controls phytoplankton dynamics in the northern San Francisco Bay estuary. Estuarine, Coastal and Shelf Science 16:415-429.

Cloern, J. and A. Jassby. 2012. Drivers of change in estuarine-coastal ecosystems: discoveries form four decades of study in San Francisco Bay. Reviews of Geophysics, 50, RG4001, doi:10.1029/2012RG000397.

Cloern, J. E., N. Knowles, L. R. Brown, D. Cayan, M. D. Dettinger, T. L. Morgan, D. H. Schoellhamer, M. T. Stacey, M. van der Wegen, R. W. Wagner, and A. D. Jassby. 2011. Projected evolution of California's San Francisco Bay-Delta-river system in a century of climate change. PLoS One 6:e24465.

Cloern, J. E., T. M. Powell, and L. M. Huzzey. 1989. Spatial and temporal variability in South San Francisco Bay (USA). II. Temporal changes in salinity, suspended sediments, and phytoplankton biomass and productivity over tidal time scales. Estuarine, Coastal and Shelf Science 28:599-613.

Conomos, T. J. 1979. Properties and circulation of San Francisco Bay waters. Pages 47-84 in T. J. Conomos, ed. San Francisco Bay: The Urbanized Estuary. Pacific Division, Amer. Assoc. Advance. Sci., San Francisco, Ca.

Cunningham, C., N. Hendrix, E. Dusek-Jennings, R. Lessard, and R. Hilborn. 2015. Delta Chinook Final Report to the Delta Science Panel.

Cury, P. M., I. L. Boyd, S. Bonhommeau, T. Anker-Nilssen, R. J. M. Crawford, R. W. Furness, J. A. Mills, E. J. Murphy, H. Österblom, M. Paleczny, J. F. Piatt, J.-P. Roux, L. Shannon, and W. J. Sydeman. 2011. Global Seabird Response to Forage Fish Depletion—One-Third for the Birds. Science 334:1703-1706.

Dege, M., and L. R. Brown. 2004. Effect of outflow on spring and summertime distribution of larval and juvenile fishes in the upper San Francisco Estuary. Pages 49–65 in F. Feyrer, L. R. Brown, R. L. Brown, and J. J. Orsi, editors. Early life history of fishes in the San Francisco estuary and watershed. American Fisheries Society, Symposium 39, Bethesda, Maryland.

ESA/PWA. 2013. Analysis Of The Costs And Benefits Of Using Tidal Marsh Restoration As A Sea Level Rise Adaptation Strategy In San Francisco Bay. Prepared for the Bay Institute.
Available at: http://thebayinstitute.blob.core.windows.net/assets/FINAL%20D211228.00%20Cost%20and%20Benefits%20of%20Marshes%20022813.pdf

Feyrer, F., J. E. Cloern, L. R. Brown, M. A. Fish, K. A. Hieb, and R. D. Baxter. 2015. Estuarine Fish Communities Respond to Climate Variability over both River and Ocean Basins. Global change biology.

Feyrer, F., K. Newman, M. Nobriga, and T. Sommer. 2010. Modeling the Effects of Future Outflow on the Abiotic Habitat of an Imperiled Estuarine Fish. Estuaries and Coasts 34:120-128.

Feyrer, F., M. L. Nobriga, T. R. Sommer. 2007. Multidecadal trends for three declining fish species: habitat patterns and mechanisms in the San Francisco Estuary, California, USA. Canadian Journal Fisheries and Aquatic Sciences 64:723-734.

Fisch, K.M., J.M. Henderson, R.S. Burton, and B. May. 2011. Population genetics and conservation implications for the endangered delta smelt in the San Francisco Bay-Delta. Conservation Genetics 12:1421–1434.

Florsheim, J. L. and M. D. Dettinger. 2015. Promoting Atmospheric-River and Snowmelt-Fueled Biogeomorphic Processes by Restoring River-Floodplain Connectivity in California's Central Valley. Chapter 6 in © Springer New York 2015 P. F. Hudson, H. Middelkoop (eds.), Geomorphic Approaches to Integrated Floodplain Management of Lowland Fluvial Systems in North America and Europe, DOI 10.1007/978-1-4939-2380-9_6.

Ford, J. K. B. & Ellis, G. M. 2006 Selective foraging by fish-eating killer whales Orcinus orca in British Columbia. Mar. Ecol. Prog. Ser. 316, 185 – 199. (doi:10.3354/ meps316185)

Ford JKB, Ellis GM, Olesiuk PF, Balcomb KC. 2010. Linking killer whale survival and prey abundance: food limitation in the oceans' apex predator? Biology Letters 6: 139–142.

Fox, J.P., T.R. Mongan, and W.J. Miller. 1991. Long term annual and seasonal trends and surface salinity of San Francisco Bay. Journal of Hydrology 122:93-117.
Goals Project. 1999. Baylands Ecosystem Habitat Goals. A report of habitat recommendations prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. U.S. Environmental Protection Agency, San Francisco, Calif./S.F. Bay Regional Water Quality Control Board, Oakland, Calif. http://baylandsgoals.org/wp-content/uploads/2015/10/1999sfbaygoals031799.pdf

Goals project. 2015. The Baylands and Climate Change: What We Can Do. Baylands Ecosystem Habitat Goals Science Update 2015 prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. California State Coastal Conservancy, Oakland, CA.

Governor's Delta Vision Blue Ribbon Task Force, 2008. Our Vision for the California Delta.

Grantham, T.E., and J.H. Viers. 2014. 100 years of California's water rights system: patterns, trends and uncertainty. Environmental Research Letters.

Grimaldo, L. F., T. Sommer. N. Van Ark, G. Jones, E. Holland, P. B. Moyle, and B. Herbold. 2009. Factors affecting fish entrainment into massive water diversions in a tidal freshwater estuary: can fish losses be managed? North American Journal of Fisheries Management 29:1253–1270.

Healy, M.C. 1991. Life history of Chinook salmon (Oncorhynchus tshawytscha), in Pacific salmon life histories, C. Groot and L. Margolis, editors, University of British Columbia Press, Vancouver, British Columbia, B.C. pp. 311-393.

Hilborn, R., Quinn, T.P., Schindler, D.E., and Rogers, D.E. 2003. Biocomplexity and fisheries sustainability. Proc. Natl. Acad. Sci. U.S.A.100(11): 65646568. doi:10.1073/pnas.1037274100.PMID:12743372.

Hughes, B. B., M. D. Levey, J. A. Brown, M. C. Fountain, A. B. Carlisle, S. Y. Litvin, C. M. Greene, W. N. Heady, and M. G. Gleason. 2014. Nursery Functions of U.S. West Coast Estuaries: The State of Knowledge for Juveniles of Focal Invertebrate and Fish Species. The Nature Conservancy, Arlington, VA. 168pp.

Hurst, M. P. and K. W. Bruland. 2008. The effects of the San Francisco Bay plume on trace metal and nutrient distributions in the Gulf of the Farallones. Geochimica et Cosmochimica Acta 72:395-411.

Interagency Ecological Program Management, Analysis and Synthesis Team (IEP MAST). 2015. An updated conceptual model of Delta Smelt biology: our evolving understanding of an estuarine fish. Technical Report 90.

Israel, J., A. Drauch, M. Gingras, and M. Donnellan. 2009. Life history conceptual model for White Sturgeon (Acipenser transmontanus). California Department of Fish and Game, Delta Regional Ecosystem Restoration and Implementation Program.

Jassby, A.D. 2008. Phytoplankton in the Upper San Francisco Estuary: Recent biomass trends, their causes and their trophic significance. San Francisco Estuary and Watershed Science 6:Article 2.

Jassby, A. D., J. E. Cloern, and B. E. Cole. 2002. Annual Primary Production: Patterns and Mechanisms of Change in a Nutrient-Rich Tidal Ecosystem. Limnology and Oceanography 47:698-712.

Jassby, A. D., W. J. Kimmerer, S. G. Monismith, C. Armor, J. E. Cloern, T. M. Powell, J. R. Schubel, and T. J. Vendlinski. 1995. Isohaline Position as a Habitat Indicator for Estuarine Populations. Ecological Applications 5:272-289.

Jassby, A. D. and E. E. Van Nieuwenhuyse. 2005. Low dissolved oxygen in an estuarine channel (San Joaquin River, California): Mechanisms and models based on long-term time series. San Francisco Estuary and Watershed Science 2:1–33.

Jin, C. 2008. Biodiversity dynamics of freshwater wetland ecosystems affected by secondary salinisation and seasonal hydrology variation: a model-based study. Hydrobiologia 598:257-270.

Kimmerer, W. J. 2002a. Effects of freshwater flow on abundance of estuarine organisms: Physical effects or trophic linkages? Marine Ecology Progress Series 243:39-55.

Kimmerer, W.J. 2002b. Physical, biological, and management responses to variable freshwater flow into the San Francisco Estuary. Estuaries 25:1275–1290.

Kimmerer, W. 2006. Response of anchovies dampens effects of the invasive bivalve Corbula amurensis on the San Francisco Estuary foodweb. Marine Ecology Progress Series 324:218.

Kimmerer, W.J. 2008. Losses of Sacramento River Chinook salmon and Delta smelt to entrainment in water diversions in the Sacramento-San Joaquin Delta. San Francisco Estuary and Watershed Science 6(2). http://www.escholarship.org/uc/ item/7v92h6fs/. Accessed April 2015

Kimmerer, W. J., E. S. Gross, and M. L. MacWilliams. 2009. Is the Response of Estuarine Nekton to Freshwater Flow in the San Francisco Estuary Explained by Variation in Habitat Volume? Estuaries and Coasts 32:375-389.

Knowles, N. 2002. Natural and management influences on freshwater inflows and salinity in the San Francisco Estuary at monthly to interannual scales. Water Resources Research: 38: 25-21-25-11.

Kohlhorst, D.W., L.W. Botsford, J. S. Brennan, and G. M. Caillet. 1991. Aspects of the structure and dynamics of an exploited central California population of white sturgeon(Acipenser transmontanus). Acipenser, P. Williot., Ed. CEMAGREF Publ., 277-293.

Kondolf, G. 2000. Changes in flow regime and sediment budget in the Sacramento-San Joaquin river system since 1850: implications for restoration planning.in CALFED Bay-Delta Program Science Conference 2000 Abstracts.

Kratville, D. 2008. Final Species Life History Conceptual Model Sacramento Splittail, Pogonichthys macrolepidotus. Sacramento-San Joaquin Delta Regional Ecosystem Restoration Implementation Plan, California Department of Fish and Wildlife, Ecosystem Restoration Program.

Largier, J. 1996. Hydrodynamic exchange between San Francisco Bay and the Ocean: The role of ocean circulation and stratification. In San Francisco Bay: The ecosystem. Pacific Division, American Association for the Advancement of Science, 69-104.

Largier, J., B. Cheng, and K. Higgason. 2011. Climate Change Impacts: Gulf of the Farallones and Cordell Bank National Marine Sanctuaries. Report of a Joint Working Group of the Gulf of the Farallones and Cordell Bank National Marine Sanctuaries Advisory Councils. Page 121 in Marine Sanctuaries Conservation Series ONMS-11-04. National Oceanic and Atmospheric Administration, Office of National Marine Sanctuaries, Silver Spring, Maryland.

Leatherbarrow J., McKee L., Ganju N., Schoellhamer D., Flegal R. July 25 2003. Presentation to RMP Sources, Pathways, and Loadings Workgroup: Quantifying loads of sediment and contaminants entering San Francisco Bay from the Central Valley: The Mallard Island Study http://www.sfei.org/sites/default/files/SPLWG_july2003_Item3a.pdf

Lehman, P., G. Boyer, C. Hall, S. Waller, and K. Gehrts. 2005. Distribution and toxicity of a new colonial Microcystis aeruginosa bloom in the San Francisco Bay Estuary, California. Hydrobiologia 541:87-99.

Lindley, S.T., C.B. Grimes, M.S. Mohr, W. Peterson, J. Stein, J.T. Anderson, L.W. Botsford, D.L. Bottom, C.A. Busack, T.K. Collier, J. Ferguson, J.C. Garza, A.M. Grover, D.G. Hankin, R.G. Kope P.W. Lawson, A. Low, R.B. MacFarlane, K. Moore, M. Palmer-Zwahlen, F.B. Schwing, J. Smith, C. Tracy, R. Webb, B.K. Wells, and T.H. Williams. 2009. What caused the Sacramento River fall Chinook salmon collapse? NOAA Technical Memorandum. NOAA-TM-NMFS-SWFSC-447. US Department of Commerce.

Luoma, Samuel N. and Presser, Theresa S. 2009. Emerging Opportunities in Management of Selenium Contamination. Environ. Sci. Technol. 43: 8483-8487.

Lyons, K. G., C. A. Brighham, B. H. Traut, and M. Schwartz. 2005. Rare species and ecosystem functioning. Conservation Biology 19:1019-1024.

MacArthur, R.H. and E.O. Wilson. 1967. The Theory of Island Biogeography. Princeton University Press. Princeton, NJ.

Mac Nally, R., J. R. Thomson, W. J. Kimmerer, F. Feyrer, K. B. Newman, A. Sih, W. A. Bennett, L. Brown, E. Fleishman, S. D. Culberson, and G. Castillo. 2010. Analysis of pelagic species decline in the upper San Francisco Estuary using multivariate autoregressive modeling (MAR). Ecological Applications 20:1417-1430.

Mahardja, B., J. L. Conrad, L. Lusher, and B. Schreier. 2015. Abundance trends, distribution, and habitat associations of the invasive Mississippi Silverside (Menidia audens) in the Sacramento-San Joaquin Delta. Submitted to San Francisco Estuary and Watershed Science.

Malamud-Roam, F., and B. L. Ingram. 2003. Holocene sediment records from San Francisco Estuary tidal marshes and their relevance to California paleo-climate variability. Page 213 in XVI Congress of the International Union for Quaternary Research; shaping the Earth; a Quaternary perspective. International Union.

Malamud-Roam, F., and B. L. Ingram. 2004. Late Holocene δ13C and pollen records of paleosalinity from tidal marshes in the San Francisco Bay estuary, California. Quaternary Research 62:134-14.

Malbrouck, C. & and P. Kestemont, 2006. Effects of microcystins on fish. Environmental Toxicology and Chemistry 25: 72–86.

Marston, D. Mesick, C. Hubbard, A., Stanton, D., Fortmann-Roe, S., Tsao, S., and Heyne, T. 2012. Delta Flow Factors Influencing Stray Rate of Escaping Adult San Joaquin River Fall-Run Chinook Salmon (Oncorhynchus tshawytscha). San Francisco Estuary and Watershed Science, 10(4). Permalink: http://www.escholarship.org/uc/item/6f88q6pf

McGrath 2001. James McGrath, Port of Oakland, oral comm., December 2001 as cited in McKee et al. 2002.

McKee, L., N. Ganju, D. Schoellhamer, J. Davis, D. Yee, J. Leatherbarrow, and R. Hoenicke. 2002. Estimates of Suspended-sediment Flux Entering San Francisco Bay from the Sacramento and San Joaquin Delta. SFEI Contribution 65.

McKee, L.J., Lewicki, M., Schoellhamer, D.H., and Ganju, N.K., 2013. Comparison of sediment supply to San Francisco Bay from Coastal and Sierra Nevada watersheds. Marine Geology 345:47–62.

Michel, C. J., A. J. Ammann, S. T. Lindley, P. T. Sandstrom, E. D. Chapman, M. J. Thomas, G. P. Singer, A. P. Klimley, and R. B. MacFarlane. 2015. Chinook salmon outmigration survival in wet and dry years in California's Sacramento River. Canadian Journal of Fisheries and Aquatic Sciences.

Miller M.A., R.M. Kudela, A. Mekebri, D. Crane, S. C. Oates, et al. 2010. Evidence for a Novel Marine Harmful Algal Bloom: Cyanotoxin (Microcystin) Transfer from Land to Sea Otters. PLoS ONE 5(9): e12576. doi:10.1371/journal.pone.0012576.

Monismith, S., Burau, J.R., and Stacey, M., 1996. Stratification dynamics and gravitational circulation in northern San Francisco Bay, In Hollibaugh, J.T., (ed.), San Francisco Bay: The Ecosystem. Pacific Division of the American Association for the Advancement of Science, San Francisco, p. 123–153. Available from http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/docs/cmnt091412/sldmwa/monismith_etal_1996.pdf

Monismith, S. G., W. Kimmerer, J. R. Burau, and M. T. Stacey. 2002. Structure and Flow-Induced Variability of the Subtidal Salinity Field in Northern San Francisco Bay. Journal of Physical Oceanography [J. Phys. Oceanogr.]. 32:3003-3019.

Moyle, P. B. 2008. The Future of Fish in Response to Large-Scale Change in the San Francisco Estuary, California. American Fisheries Society Symposium 64:357-374.

National Marine Fisheries Service (NMFS). 2009. Central Valley Salmon Recovery Plan – public Draft.

National Oceanic and Atmospheric Administration (NOAA). 2015. 2015 Elevated California Sea Lions Strandings in California: FAQs. Available at http://www.westcoast.fisheries.noaa.gov/mediacenter/faq_2015_ca_sea_lion_strandings.pdf

National Research Council (NRC). 2010. A Scientific Assessment of Alternatives for Reducing Water Management Effects on Threatened and Endangered Fishes in California's Bay Delta. Committee on Sustainable Water and Environmental Management in the California Bay-Delta; ISBN: 0-309-12803-X, 104 pages.

Nichols, F. H., J. E. Cloern, S. N. Luoma, and D. H. Peterson. 1986. The Modification of an Estuary. Science 231:567-573.

Nichols, F.H., J.K. Thompson, and L.E. Schemel. 1990. Remarkable invasion of San-Francisco Bay (California, USA) by the Asian clam Potamocorbula amurensis. 2. Displacement of a former community. Marine Ecology Progress Series 66: 95–101.

Nichols, Frederic H. & Pamatmat, Mario M. 1988. The Ecology of the soft-bottom benthos of San Francisco Bay: A community profile. USFWS Biological Report 85(7.19). 73 pp. Available at http://www.nwrc.usgs.gov/techrpt/85-7-23.pdf

Nobriga, M. L., and J. A. Rosenfield. 2016. Population Dynamics of an Estuarine Forage Fish: Disaggregating Forces Driving Long-Term Decline of Longfin Smelt in California's San Francisco Estuary. Transactions of the American Fisheries Society 145:44-58.

Nobriga, M.L., T.R. Sommer, F. Feyrer, and K. Fleming. 2008. Long-term Trends in summertime habitat suitability for Delta smelt (Hypomesus transpacificus). San Francisco Estuary and Watershed Science. 6(1):, Article 1.

Nyman, J., R. DeLaune, and W. Patrick. 1990. Wetland soil formation in the rapidly subsiding Mississippi River deltaic plain: Mineral and organic matter relationships. Estuarine, Coastal and Shelf Science 31:57-69.

Odum, W.E. 1970. Insidious alteration of the estuarine environment. Trans. Am. Fish Soc., 88, 836-847.

Okamoto, A.R. 2014. Shifts in selenium spike. Estuary News, June 2014, Vol. 23 No. 2.

Pacific Fishery Management Council (PFMC). 2015. Stock Assessment and Fishery Evaluation (SAFE) Documents: Review of 2015 Ocean Salmon Fisheries, Appendix D: Historical Economic Data. Available at: http://www.pcouncil.org/wp-content/uploads/2016/02/salsafe2015_Appendix_D.pdf

Pacific Institute and Natural Resources Defense Council (NRDC). 2014. The untapped potential of CA's water supply. available at: http://pacinst.org/publication/ca-water-supply-solutions/

Parker, V. T., J. C. Callaway, L. M. Schile, M. C. Vasey, and E. R. Herbert. 2011. Climate Change and San Francisco Bay-Delta Tidal Wetlands. San Francisco Estuary and Watershed Science 9.

Pearson, D.E. 1989. Survey of fishes and water properties of South San Francisco Bay, California, 1973-1982. NOAA-NMFS Technical Report 78.

Peterson, D.H., D.R. Cayan, J. DiLeo, M. Noble, and M. Dettinger, 1994. The role of climate in estuarine variability. American Scientist, 83, 58-67. (27)

Peterson, D. H., D. R. Cayan, M. D. Dettinger, M. A. Noble, L. G. Riddle, L. E. Schemel, R. E. Smith, R. J. Uncles AND R. A. Walters. 1996. San Francisco Bay Salinity: Observations, Numerical Simulation, and Statistical Models.

Peterson, H. and Vayssieres, M. 2010. Benthic Assemblage Variability in the Upper San Francisco Estuary: A 27-Year Retrospective. San Francisco Estuary and Watershed Science, 8(1). Available at: http://escholarship.org/uc/item/4d0616c6

Poff, N.L., Zimmerman, J.K.H., 2010. Ecological responses to altered flow regimes: a literature review to inform the science and management of environmental flows. Freshw. Biol. 55, 194–205.

Porterfield, G. 1980. Sediment transport of streams tributary to San Francisco, San Pablo, and Suisun Bays, California, 1909–1966. U.S. Geolological Survey Water Resour. Invest. Rep., 80-64, 91 pp.

PWA 2002. Phillip Williams, Phillip Williams & Associates, oral comm., March 2002 as cited in McKee et al. 2002 (PWA 2002).

Quinn, T.P., 2005. The behavior and ecology of Pacific salmon and trout. Seattle: University of Washington Press.

Ralston, S. 2005. An assessment of starry flounder off California, Oregon, and Washington. NOAA Fisheries, Southwest Fisheries Science Center.

Richter, B. D., M. M. Davis, C. Apse, and C. Konrad. 2011. A presumptive standard for environmental flow protection. River Research and Applications 28:1312-1321.

Robins J., Mayer D, Stauton-Smith J, Halliday I, Sawynok B, Sellin M. 2006. Variable growth rates of the tropical estuarine fish barramundi Lates calcarifer (Bloch) under different freshwater flow conditions. Journal of Fish Biology 69:379-391.

Rosenfield, J. A. 2002. Pattern and process in the geographical ranges of freshwater fishes. Global Ecology and Biogeography 11:323-332.

Rosenfield, J. A., and R. D. Baxter. 2007. Population dynamics and distribution patterns of longfin smelt in the San Francisco estuary. Transactions of the American Fisheries Society 136:1577-1592.

Sanderson, E. W, S. L. Ustin, and T. Foin. 2000. The influence of tidal channels on the distribution of salt marsh plant species in Petaluma Marsh, CA, USA. Plant Ecology 146:29-41.

San Francisco Estuary Institute (SFEI). 2015. The Pulse of the Bay: The State of Bay Water Quality, 2015 and 2065. SFEI Contribution #759. San Francisco Estuary Institute, Richmond, CA. Available at: http://www.sfei.org/sites/default/files/biblio_files/2015_RMP_PULSE.pdf

San Francisco Estuary Partnership (SFEP). 2015. The State of the Estuary Report (SOTER).

Satterthwaite, W.H., S.M. Carlson, S.D. Allen-Moran, S. Vincenzi, S.J. Bograd, B.K. Wells. 2014. Match-mismatch dynamics and the relationship between ocean-entry timing and relative ocean recoveries of Central Valley fall run Chinook salmon. Marine Ecology Progress Series. 511: 237–248.

Scientific Evaluation Process (SEP) Group. unpublished. Interim objectives for restoring Chinook salmon (Oncorhynchus tshawytscha) and O. myiss in the Stanislaus River, Administrative Draft. (The SEP Group includes scientific experts from American Rivers, The Bay Institute, The Nature Conservancy, Trout Unlimited, and state and federal agencies). September 2015.

Schoellhamer, D. 2009. Suspended sediment in the Bay: Past a tipping point. Oakland, CA: San Francisco Estuary Institute, 56–65. Available: http://www.sfei.org/sites/default/files/RMP_Pulse09_no583_final4web.pdf.

Schoellhamer, D. H., S. A. Wright, J. Z. Drexler. 2013. Adjustment of the San Francisco estuary and watershed to decreasing sediment supply in the 20th century. Marine Geology 345:63-71.

Sommer, T., C. Armor, R. Baxter, R. Breuer, L. Brown, M. Chotkowski, S. Culberson, F. Feyrer, M. Gingras, B. Herbold, W. Kimmerer, A. Mueller-Solger, M. Nobriga, and K. Souza. 2007. The collapse of pelagic fishes in the Upper San Francisco Estuary. Fisheries (Bethesda) 32:270-277.

Sommer, T., F. H. Mejia, M. L. Nobriga, F. Feyrer, and L. Grimaldo. 2011. The spawning migration of delta smelt in the upper San Francisco Estuary. San Francisco Estuary and Watershed Science 9.

Sommer, T., and F. Mejia. 2013. A place to call home: a synthesis of delta smelt habitat in the upper San Francisco Estuary. San Francisco Estuary and Watershed Science 11(2). Available at: http://www.escholarship.org/uc/ item/32c8t244.

Stahle, D. W., M. D. Therrell, and M. K. Cleaveland. 2001. Ancient Blue Oaks Reveal Human Impact on San Francisco Bay Salinity. EOS, Transactions of the American Geophysical Union 82:141-145.

State Water Resources Control Board (SWRCB). 2010. Development of Flow Criteria for the Sacramento- San Joaquin Delta Ecosystem. Prepared Pursuant to the Sacramento-San Joaquin Delta Reform Act of 2009. http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/deltaflow/docs/final_rpt080310.pdf

Stewart, A.R., Luoma, S.N., Elrick, K.A., Carter,J.L., and van der Wegen, M. 2013. Influence of estuarine processes on spatiotemporal variation in bioavailable selenium. Marine Ecology Progress Series 492:41-56.

Stevens, D.E. & and L.W. Miller. 1983. Effects of river flow on abundance of young Chinook salmon, American shad, longfin smelt, and delta smelt in the Sacramento-San Joaquin River system. North American Journal of Fisheries Management 3:425-437.

Stine, S. 1994. Extreme and persistent drought in California and Patagonia during mediaeval time. Letters to Nature, Department of Geography and Environmental Studies, California State University, Hayward, California, v. 369.

Stine, S. 1996. Climate, 1650-1850. In Sierra Nevada Ecosystem Project (SNEP): Final Report to Congress. Vol. II: Assessments and Scientific Basis for R-37 Management Options. University of California. Wildland Resources Center Report No. 37. University of California, Davis, CA. 1528 pp.

Stralberg, D., M. Brennan, J.C. Callaway, J. K. Wood, L. M. Schile, D. Jongsomjit, M. Kelly, T. Parker, and S. Crooks, 2011. Evaluating Tidal Marsh Sustainability in the Face of Sea Level Rise: A Hybrid Modeling Approach Applied to San Francisco Bay. PLoS ONE 6(11).

Sturrock, A. M., J. D. Wikert, T. Heyne, C. Mesick, A. E. Hubbard, T. M. Hinkelman, P. K. Weber, G. E. Whitman, J. J. Glessner, and R. C. Johnson. 2015. Reconstructing the Migratory Behavior and Long-Term Survivorship of Juvenile Chinook Salmon under Contrasting Hydrologic Regimes. PLoS One 10:e0122380.

Takekawa, J. W., H. Spautz, N. Nur, J. L. Greenier, K. Malamud-Roam, J. C. Nordby, A. Cohen, F. Malamud-Roam, and S. E. Wainwright-De la Cruz. 2006. Environmental threats to tidal marsh vertebrates of the San Francisco Bay Estuary. Studies in Avian Biology 32:176-197.

The Bay Institute (TBI). 1998. From the Sierra to the Sea: The Ecological History of the San Francisco Bay-Delta Watershed. Available at www.bay.org/publications/from -the-sierra-to-the-sea-the-ecological-history-of-the-san-francisco-bay-delta-waters

The Bay Institute (TBI). 2010. Gone with the Flow. Available at http://www.thebayinstitute.org/resources/publications/gone-with-the-flow

The Bay Institute (TBI). 2012. Collateral Damage. Available at http://www.thebayinstitute.org/resources/publications/collateral-damage

The Bay Institute, American Rivers, Environmental Defense Fund, Natural Heritage Institute, and Natural Resources Defense Council. [TBI et al. 2010 exhibits 1-4]. 2010. Written Testimony of Jonathan Rosenfield, Christina Swanson, John Cain, et al. Before the State Water Resources Control Board, Exhibits 1-4, summary, and closing comments. Available at: http://www.bay.org/publications/flow-criteria-for-the-delta-ecosystem

Thomson, J. R., W. J. Kimmerer, L. R. Brown, K. B. Newman, R. Mac Nally, W. A. Bennett, F. Feyrer, and E. Fleishman. 2010. Bayesian change point analysis of abundance trends for pelagic fishes in the upper San Francisco Estuary. Ecological Applications 20:1431-1448.

Tobias, Jimmy. September 16, 2014. Ocean Beach's Sand Supply Dries Up, Leaving Plovers Squeezed. Bay Nature. Available at http://baynature.org/article/ocean-beachs-sand-supply-dries-leaving-plovers-stranded/

U.S. Bureau of Reclamation (USBR). 2012. 2012 deliveries summary. Available at: http://www.usbr.gov/mp/cvo/12deliv.html

U.S. Bureau of Reclamation (USBR). 2016. New Melones operations modeling spreadsheet.

U.S. Environmental Protection Agency USEPA). 2012. Water Quality Challenges in the San Francisco Bay/Sacramento-San Joaquin Delta Estuary: EPA's Action Plan.

U.S. Fish and Wildlife Service (USFWS). 1995a. Recovery plan for the Sacramento/San Joaquin Delta native fishes.

University of California, Santa Cruz. 2015. Assessing SPATT in San Francisco Bay. SFEI Contract 1051. Final Report. Submitted to San Francisco Estuary Institute. Available at: http://sfbaynutrients.sfei.org/sites/default/files/SPATT Final Report May2015.pdf

Walters, R.A., Cheng, R.T., Conomos, T.J. 1985. Time scales of circulation and mixing processes of San Francisco Bay waters. Hydrobiologia 129, 13-36.

Ward, E. J., E. E. Holmes, and K. C. Balcomb. 2009. Quantifying the effects of prey abundance on killer whale reproduction. Journal of Applied Ecology 46: 632–640.

Williams, J. G. 2006. Central Valley Salmon: A Perspective on Chinook and Steelhead in the Central Valley of California. San Francisco Estuary and Watershed Science 4.

Winder, M., and A. D. Jassby. 2010. Shifts in zooplankton community structure: Implications for food-web processes in the upper San Francisco Estuary, Estuaries Coasts, 34(4), 675–690, doi:10.1007/s12237-010-9342

Winder, M., A. D. Jassby, and R. Mac Nally. 2011. Synergies between climate anomalies and hydrological modifications facilitate estuarine biotic invasions, Ecol. Lett., 14, 749–757, doi:10.1111/j.1461-0248.2011.01635.x

Wright, S.A., D.H. Schoellhamer. 2004. Trends in the sediment yield of the Sacramento River, California, 1957–2001. San Francisco Estuary and Watershed Science 2 (2).

GLOSSARY

Abundance
The number of individuals in a population. Often measured as an index calculated based on the number of individuals detected per sample.

Actual Flow or Runoff
The amount of fresh water flowing past a point, measured or calculated at that point or calculated based as the sum of upstream measurements throughout a watershed; in contrast to unimpaired flow or runoff (see below).

Acre Foot (AF)
The amount of water required to cover 1 acre to a depth of 1 foot (approx. the area of an American football field). An acre-foot is approximately 326,000 gallons or 1,233.5 cubic meters.

Algae
Chlorophyll containing single or multi-celled organisms that lives in fresh or salt water.

Anadromous Fish
Fish that are born in freshwater, migrate to the ocean, and return to fresh water in order to as adults to spawn. Anadromous fish in the Bay's watershed include Chinook salmon, steelhead, striped bass, white sturgeon, green sturgeon, and American shad.

Aquifer
An underground geological formation that holds water.

Bay
A body of water connected to an ocean or lake, formed by an indentation of the shoreline.

Bay Inflow

Freshwater flows to San Francisco Bay, originating upstream from its Central Valley watershed, measured or estimated where the Delta enters Suisun Bay (the uppermost portion of San Francisco Bay), and not including the relatively small amount of flow from the local watersheds directly surrounding the Bay.

Benthic

Bottom-dwelling. Refers to organisms that live on the bottom of a water body or the habitat along the bed of a river, estuary, lake, or sea.

Brackish water

Slightly salty water, characteristic of estuarine habitats.

Central Valley Project (CVP)

The federally operated water storage, diversion, and conveyance system that provides water from California's Central Valley and the Trinity River to agricultural, municipal, and industrial users in the Central Valley and Bay Area. Major facilities include Shasta, Trinity, Folsom, Friant, and New Melones Dams (and their reservoirs), the Delta Cross Channel, the Delta-Mendota Canal, the Jones (Tracy) Pumping Plant, and San Luis Reservoir among others.

CFS

Cubic feet per second, a rate of flow measured as a volume of water (cubic feet) passing a point in one second. A flow of 1cfs equals about 2 acre-feet per day or enough to fill a 32-gallon trashcan in just over 4 seconds.

Delta

The uppermost portion of the San Francisco Bay estuary, the Delta is the roughly triangular area formed at the western edge of the Central Valley by the confluence of the Sacramento and San Joaquin Rivers. Bay inflow from the Central Valley passes through the Delta as do numerous types of migratory fish species.

Diversion

See "Water Diversion"

Drought

An extended period, lasting more than one year, during which precipitation and runoff is well below average. Different from the seasonal drought experienced in California every year from late spring through early fall when very little or no rain falls.

Ecosystem

The biological and abiotic (non-living) parts of the environment in a particular area and the interaction of those parts.

Endangered Species

Species or distinct populations of plants and animals that are protected by federal or state laws that are specifically intended to prevent extinction and to protect habitats of those species.

Erosion

The wearing away of the land surface by wind or water.

Export

See “Water Export”

Estuary

A partly enclosed coastal body of brackish water with one or more rivers or streams flowing into it, and with a free connection to the open ocean. Estuaries are formed by the mixing of fresh water and saline water and represent a transition zone between river environments and marine environments.

Habitat

The physical, chemical, and biological context within which an organism or assemblage of organisms live.

Harmful algal bloom (HAB, aka Toxic algal bloom)

A proliferation of cyanobacteria that cause negative impacts to other organisms via natural production of toxins.

Introduced (or “exotic”) species

Populations of plants and animals that are not native to a specific area, which become established and self-sustaining after individuals have been transported into an ecosystem intentionally or unintentionally. Introduced species may alter the natural ecology of an area, via competition for resources, alteration of ecosystem processes and native habitats, and/or predation on native species.

Microcystis
A genus of cyanobacteria that lives in fresh water and produces a powerful toxin (microcystin).

MAF
Million acre-feet.

Nutrient
Any substance, which enhances the growth of plants and animals.

Pacific Flyway
A major north-south corridor for migratory birds on the west coast of the Americas, extending from Alaska to Patagonia. Every year, migratory birds travel some or all of this distance both in spring and in fall, following food sources, heading to breeding grounds, or travelling to overwintering sites.

Plankton
A diverse group of organisms that live in the water column of large bodies of water and that cannot swim against a current. Includes photosynthetic organisms (phytoplankton) and tiny primary consumers (zooplankton). They provide a crucial source of food to many large aquatic organisms, such as fish and whales.

Population Viability
The ability of a population to persist and to avoid extinction. The viability of a population reflects the number of individuals, changes in the birth rate, mortality rate, fecundity, genetic and life-history diversity of individuals in a population, and geographic distribution.

Productivity
Relates to factors such as birth, maturation, and death rates that determine a population's growth rate.

Residence Time
The average amount of time that a moving particle (e.g., molecule of water) spends in a particular area.

Runoff
The portion of precipitation that enters surface waters during a given period of time. In California, on average about one-third of the precipitation becomes runoff while the rest is "consumed" – evaporated and transpired – by plants or evaporated from the ground.

Salmon

A common name for at least six species of fish. Four races of Chinook salmon reproduce in the rivers of the Central Valley – more distinct populations of this species than in any other single watershed in their range. Named for the time of year during which they re-enter freshwater and begin their migration upstream to spawn, these races (or "runs") are the spring, fall, late-fall and winter runs.

Salinity Gradient

The spatial distribution of the range of salinities between fresh and marine that is one of the defining characteristics of any estuarine ecosystem. This gradient generates a range of habitats and ecological assemblages composed of organisms with different tolerances for salinity.

San Francisco Bay

The central portion of the Bay estuary, composed of the open water embayments (from north to south, Suisun, San Pablo, Central and South Bays) upstream of the Golden Gate and downstream from the Delta.

San Francisco Bay Estuary

The area – of which San Francisco Bay is the central region – where fresh water and salt water mix, from the tidally influenced portions of the Sacramento – San Joaquin Delta where river flows enter the estuary to local nearshore waters in the Gulf of the Farallones outside the Golden Gate.

Sediment

Fine soil or mineral particles that settle to the bottom of the water or are suspended in the water.

Spatial Distribution

The arrangement of a population in space. Not to be confused with dispersal, which is the movement of individuals away from the area where they were born. Distribution patterns can change throughout a species' life cycle – the population is generally considered to be at greatest risk when its geographic range is most limited or in life stages that are least mobile.

State Water Project (SWP)

The state-operated water storage, diversion, and conveyance system that provides water from the Feather River and "surplus" water to agricultural, municipal, and industrial users. Major facilities include Oroville Dam and Reservoir, the Banks Delta Pumping Plant, the California, South Bay, and North Bay Aqueducts, San Luis Reservoir, and Castaic Lake.

TAF

Thousand acre-feet.

Toxic Algal Blooms

(see Harmful Algal Blooms)

Trophic Levels

The relative position an organism occupies in a food web – what it eats and what eats it. The word trophic derives from the Greek trophē referring to food or feeding. Phytoplankton are primary producers. Organisms that eat phytoplankton are primary consumers. Organisms that eat animals (either as part of their diet or exclusively) are secondary consumers. These organisms all exist at different trophic levels. Individuals may change trophic levels as they pass through different life stages.

Turbidity

The cloudiness or haziness of water caused by tiny particles -- similar to smoke in air. Turbidity is roughly the opposite of water clarity.

Unimpaired Flow or Runoff

Quantity of water that would have flowed passed a point without upstream dams or water diversions (which would "impair" the runoff from reaching that point). Unimpaired runoff is calculated with existing land use (but without dams and diversions) and does not assume that the landscape has been returned to its historic, "natural" state.

Watershed

The total land surface that drains water to a particular waterbody.

Water Diversion

Removal of water from its natural course in order to serve human purposes (e.g., agricultural irrigation).

Water Export

A specific type of water diversion where water is removed from its watershed of origin and transported to an entirely different watershed or moved back upstream in the same watershed. The largest export project involves pumping water from the Delta portion of the San Francisco Bay Estuary via the State Water Project and federal Central Valley Project pumps to the San Joaquin Valley and Southern California.

Wetlands

Areas where saturation with water is the dominant factor determining the nature of soil development. These areas can be identified, even when soils are temporarily drier, by unique plants that have adapted to oxygen-deficient (anaerobic) soils. Wetlands may be very productive and diverse habitats and influence the rate of flow and water quality in adjacent environments.