Staff Report

PERIODIC REVIEW OF THE 2006 WATER QUALITY CONTROL PLAN FOR THE SAN FRANCISCO BAY/SACRAMENTO-SAN JOAQUIN DELTA ESTUARY

DRAFT

STATE WATER RESOURCES CONTROL BOARD

CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY

STATE OF CALIFORNIA
Arnold Schwarzenegger, *Governor*

CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY
Linda S. Adams, *Secretary*

STATE WATER RESOURCES CONTROL BOARD
P.O. Box 100
Sacramento, CA 95812-0100
(916) 341-5250
www.waterboards.ca.gov

Charles R. Hoppin, *Board Chair*
Frances Spivy-Weber, *Vice Chair*
Tam M. Doduc, *Member*
Arthur G. Baggett, Jr., *Member*
Dorothy Rice, *Executive Director*

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ACRONYMS AND ABBREVIATIONS

AFRP	Anadromous Fish Restoration Program
Bay-Delta	San Francisco Bay/Sacramento-San Joaquin Delta Estuary including Suisun Marsh
Bay-Delta Plan or Plan	Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary
BDCP	Bay Delta Conservation Program
BO	Biological Opinion
Central Valley Water Board	Central Valley Regional Water Quality Control Board
CEQA	California Environmental Quality Act
CESA	California Endangered Species Act
cfs	cubic feet per second
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
CVRWQCB	Central Valley Regional Water Quality Control Board
CWT	Contaminants Work Team
DCC	Delta Cross Channel
Delta	Confluence of the Sacramento River and San Joaquin River (as defined in Water Code section 12220)
DFG	California Department of Fish and Game
DSM2	Delta Simulation Model 2
DWR	California Department of Water Resources
E/I	Export/ Inflow ratio
EC	Electrical Conductivity
EIS/EIR	A joint Environmental Impact Statement prepared by lead State and federal agencies
EMP	Environmental Monitoring Program
ERP	Ecological Restoration Program
ESA	Endangered Species Act
IEP	Interagency Ecological Program
µmol/L	micromoles per liter
mg/L	milligrams per liter
mmhos/cm	millimhos per centimeter
Monitoring Program	Monitoring and Special Study Program
MWQI	Municipal Water Quality Investigations program
NDOI	Net Delta Outflow Index
NOAA Fisheries	National Marine Fisheries Service
NOP	Notice of Preparation
NPDES	National Pollutant Discharge Elimination System
NWQAP	National Water-Quality Assessment Program
OCAP	Operations Criteria and Plan
OPs	Organophosphate pesticides
POD	Pelagic Organism Decline
PYs	Personnel Years
PPIC	Public Policy Institute of California
ppt	parts per thousand
RMP	Regional Monitoring Program
ROD	Record of Decision

SEW	Suisun Ecological Workgroup
SJRA	San Joaquin River Agreement
SJRGA	San Joaquin River Group Authority
SMCG	Suisun Marsh Charter Group
SMSCG	Suisun Marsh Salinity Control Gate
SRCD	Suisun Resource Conservation District
SRWTP	Sacramento Regional Wastewater Treatment Plant
Staff Report	Periodic Review Staff Report
State Water Board	State Water Resources Control Board
SWAMP	Surface Water Ambient Monitoring Program
SWP	State Water Project
SWRCB	State Water Resources Control Board
Task Force	Blue Ribbon Task Force
The Delta	Sacramento River and San Joaquin River
TMDL	Total Maximum Daily Load
TNC	The Nature Conservancy
USBR	United States Bureau of Reclamation
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VAMP	Vernalis Adaptive Management Plan

STAFF REPORT

2009 PERIODIC REVIEW
OF THE
2006 WATER QUALITY CONTROL PLAN FOR THE SAN FRANCISCO BAY/SACRAMENTO-SAN JOAQUIN DELTA ESTUARY

Executive Summary

The State Water Resources Control Board (State Water Board) initiated its periodic review[1] of the 2006 Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (Bay-Delta; Bay-Delta Plan), on August 29, 2008, by issuing a notice of public workshop to receive comments from agencies and members of the public regarding potential modifications of the Bay-Delta Plan. In addition to the information received at the workshop[2], State Water Board staff also reviewed scientific literature and other pertinent information to develop recommendations concerning what issues should be further evaluated during the basin planning process to determine what, if any, changes should be made to the Bay-Delta Plan. This Periodic Review Staff Report (Staff Report) focuses on key issues concerning the Bay-Delta's ecology and water quality, including those that were identified in the State Water Board's August 29, 2008 "Request for Written Input on Factual Issues Regarding the Bay-Delta." For each issue, the Staff Report includes a description of the issue, staff's recommendation related to that issue, a brief discussion regarding the current scientific understanding of the issue, and a conclusion. Of the issues discussed in the Staff Report, staff recommends further review in the basin planning process of the following:

Delta Outflow Objectives
Export/Inflow Objectives
Delta Cross Channel Gate Closure Objectives
Suisun Marsh Objectives
Reverse Flow Objectives
Floodplain Habitat Flow Objectives
Changes to the Monitoring and Special Studies Program
Other Changes to the Program of Implementation

The Staff Report also includes a discussion of two issues that have already been identified for further review in the basin planning process: southern Delta salinity and San Joaquin River flow objectives.

Staff recommends that the following issues not be reviewed further in the basin planning process at this time, but instead be addressed as recommended in the associated discussion for each issue:

[1] Water Code section 13240 requires that water quality control plans be periodically reviewed. Federal Clean Water Act section 303(c) (33 U.S.C. § 1313(c)) requires a triennial review of state water quality "standards." Under the terminology of the Clean Water Act, water quality standards include designated uses and water quality criteria based on those uses. The review under Water Code section 13240 ordinarily is combined with any review required under federal law.

[2] While staff reviewed the comments that were submitted for the periodic review workshop and related proceedings (including comments submitted in response to the State Water Board's August 29, 2008 "Request for Written Input on Factual Issues Regarding the Bay-Delta"), the staff report summarizes and responds only to those comments relevant to the current periodic review.

Ammonia
Toxicity
Fish Screens
Biological Indicators

While staff recommends that certain issues be further reviewed in the basin planning process, such a recommendation does not necessarily mean that changes will be made to the Bay-Delta Plan related to these issues. Further, the State Water Board may review and consider other changes to the Bay-Delta Plan not included in the above list if new information warrants such a review. Specifically, additional changes may need to be considered where objectives are linked through flow and water quality. For example, the Sacramento River flow objective at Rio Vista is not discussed in the Staff Report but changes could be considered to this objective to make it consistent with any potential changes to the Delta Outflow Objectives. All such potential changes to the Bay-Delta Plan are not identified because they are not the primary drivers for changes to the Bay-Delta Plan, and the analyses required to identify all such changes have not been done. As the State Water Board proceeds through the basin planning process, additional issues may be identified, including changes required as part of the Bay Delta Conservation Plan (BDCP).

The State Water Board has already begun the basin planning process for southern Delta salinity and San Joaquin River Flow objectives and will begin the planning process for other issues recommended for further review immediately following adoption of this Staff Report. The State Water Board held an initial California Environmental Quality Act (CEQA) scoping meeting for the potential update and implementation of the Bay-Delta Plan and a basin planning workshop on the southern Delta salinity and San Joaquin River Flow objectives in spring 2009. The State Water Board may issue a supplemental notice of preparation (NOP) and conduct one or more additional scoping meetings as necessary for any other issues recommended for further review once this Staff Report is adopted. Staff will review information received at those meetings and workshops, and other available scientific information in order to develop recommendations for any needed changes to the Bay-Delta Plan. Staff will then prepare draft Plan amendments or a draft revised Plan for consideration by the State Water Board and any required environmental documentation. At that time, interested persons will have the opportunity, at a public hearing, to comment on staff's recommendations and on the environmental analysis. After the hearing, the State Water Board will consider adopting any proposed changes.

The Bay-Delta Plan and other related documents are posted on the State Water Board's Division of Water Rights' website at:
http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/.

I. Introduction

On December 13, 2006, the State Water Board adopted the current Bay-Delta Plan. The Bay-Delta Plan identifies beneficial uses of the Bay-Delta, including Suisun Marsh, water quality objectives for the reasonable protection of those beneficial uses, and a program of implementation for achieving the water quality objectives. The Bay-Delta Plan also identifies a number of emerging issues that require additional evaluation and basin planning activities: the pelagic organism decline (POD), climate change, Delta and Central Valley salinity, and San Joaquin River flows.

The California Water Code and the federal Clean Water Act require, respectively, a periodic review of water quality objectives and a triennial review of standards. Accordingly, the State Water Board is conducting this review of the Bay-Delta Plan. This Staff Report identifies water quality issues that should be addressed through the basin planning process. It recommends investigating whether certain existing elements of the Bay-Delta Plan should be revised, and identifies potential new elements that should be considered for inclusion in the basin plan. The Staff Report also identifies issues that should not be considered further in this basin planning process, but should instead be addressed through other venues. The Staff Report provides recommendations regarding several of the most significant issues of concern in the Bay-Delta watershed that could be addressed in the Bay-Delta Plan. The Staff Report does not provide recommendations for all elements of the Bay-Delta Plan or other potential issues. Additional issues may be considered for potential basin plan amendment at a later date, as appropriate.

With respect to the emerging issues identified in the Bay-Delta Plan, the Staff Report reiterates the State Water Board's commitment to continue ongoing basin planning efforts relating to southern Delta salinity and San Joaquin River flows. Basin planning activities related to the POD and climate change will be encompassed in the basin planning activities for all of the objectives being reviewed. As appropriate, additional objectives may also be considered to address the POD and climate change during the basin planning process.

II. Background

The Bay-Delta includes the Sacramento-San Joaquin Delta (Delta), Suisun Marsh, and the San Francisco Bay. The Delta is composed of about 738,000 acres of which about 48,000 acres are water surface area; Suisun Marsh comprises approximately 85,000 acres of marshland and water ways; and San Francisco Bay includes about 306,400 acres of water surface area. The Delta and Suisun Marsh are located where California's two major river systems, the Sacramento and San Joaquin Rivers, converge to flow westward, meeting incoming seawater from the Pacific Ocean through San Francisco Bay. The Delta is bordered by the cities of Sacramento to the north, Stockton and Tracy to the south, and Pittsburg to the west. This former wetland area has been reclaimed into more than 60 islands and tracts that are now devoted primarily to farming. The Delta is interlaced with about 700 miles of waterways. A network of levees protects the islands and tracts from flooding, most of which lie near or below sea level. The Sacramento and San Joaquin river systems drain water from about 40 percent of California's land area and support a variety of beneficial uses. The Bay-Delta Estuary is one of the largest, most important estuarine systems for fish and waterfowl production on the Pacific Coast of the United States. About 90 species of fish are found in the Delta. The Delta's channels serve as a migratory route and nursery area for Chinook salmon, striped bass, white and green sturgeon, American shad, and steelhead trout. These anadromous fishes spend most of their adult lives either in the lower bays of the estuary or in the ocean. The Delta is a major nursery area for

most of these species. Other resident fishes in the estuary include delta smelt, longfin smelt, Sacramento splittail, catfish, largemouth bass, black bass, crappie, and bluegill.

Given the Bay-Delta's importance to California's economy and environment, the State Water Board and its predecessors have undertaken numerous proceedings regarding water quality and water rights within the Bay-Delta's tributary watersheds and the protection of beneficial uses in the Bay-Delta. The 2006 Bay-Delta Plan was adopted in December of 2006 following a review of the 1995 Bay-Delta Plan, which superseded the Water Quality Control Plan for Salinity (adopted in May 1991) and the Water Quality Control Plan for the Sacramento-San Joaquin Delta and Suisun Marsh (adopted in August 1978).

Related Proceedings

Other planning and recovery efforts are currently underway to address concerns related to protection of beneficial uses in the Bay-Delta, water supply and reliability, and other issues. The State Water Board will consider and refer to information developed during preparation of other agencies' Bay-Delta related processes during its own water quality control planning and environmental review processes. The State Water Board, however, may determine that information developed by other agencies in these concurrent Bay-Delta processes does not sufficiently inform the board's own water quality planning or environmental review processes, including its review of environmental impacts of proposed amendments and alternatives. It may then prepare additional analyses. Any final environmental document will reflect the independent judgment of the State Water Board.

The BDCP is being developed under the State and federal endangered species acts and other laws in order to address ecological needs of at-risk Delta species, primarily fisheries, while improving and securing a reliable water supply. A joint Environmental Impact Statement/Environmental Impact Report (EIS/EIR), to be prepared by lead State and federal agencies, will include an analysis of the environmental impacts of improved water conveyance infrastructure and habitat conservation measures. Implementation of the BDCP will likely require changes to the Bay-Delta Plan and water rights implementing that plan.

The Central Valley Regional Water Quality Control Board's (Central Valley Water Board) environmental review for establishment of standards and a Total Maximum Daily Load (TMDL) for salinity and boron in the lower San Joaquin River upstream of Vernalis may also inform the State Water Board's project and environmental review. The Central Valley Water Board and State Water Board have also initiated a comprehensive effort to address salinity and nitrate problems in California's Central Valley and to adopt long-term solutions that will lead to enhanced water quality and economic sustainability. The Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS) effort is a collaborative basin planning effort aimed at developing and implementing a comprehensive salinity and nitrate management program. State Water Board salinity efforts will be integrated with CV-SALTS.

By Executive Order S-17-06, Governor Schwarzenegger established the Delta Vision Blue Ribbon Task Force (Task Force), which was charged with developing both a long-term vision for sustainable management of the Delta and a plan to implement that vision. The Task Force recommended, in part, two co-equal goals: restore the Delta ecosystem and create a reliable water supply for California. The Delta Vision Strategic Plan was approved and adopted by the Task Force on October 17, 2008. As part of the Strategic Plan, the Task Force recommends implementation of a dual conveyance approach to carry water to export pumps, construction of storage facilities, and large scale ecosystem restoration in the Delta. The Delta Vision Committee, a Committee consisting of five of the Governor's Cabinet Secretaries, reviewed the

Delta Strategic Plan and made implementation recommendations to the Governor and Legislature on December 31, 2008, that should be undertaken in the next two years.

In July of 2008, the State Water Board adopted a Bay-Delta Strategic Workplan (Workplan) for activities by the State Water Board, Central Valley Water Board, and San Francisco Bay Regional Water Quality Control Board to protect beneficial uses in the Bay-Delta (State Water Board 2008a). The Workplan calls for a comprehensive review of the Bay-Delta Plan, water rights, and other activities to protect fish and wildlife beneficial uses. Preparation and adoption of this Staff Report are part of that process. Per the Workplan, 4 or 5 Personnel Years (PYs) per year will be needed to conduct this comprehensive review. In addition, the Workplan commits to a review and potential amendment of the southern Delta salinity and San Joaquin River flow objectives. Per the Workplan, 3 PYs per year and $2.7 million in contract resources will be needed to conduct this southern Delta salinity and San Joaquin River flow work.

Fisheries Declines

Marked declines in four pelagic fishes in the Delta (delta smelt, longfin smelt, striped bass, and threadfin shad) became collectively known as the POD, following record and near-record lows in abundance indices that abruptly began around 2000. In response to the declines, the Interagency Ecological Program (IEP), consisting of various state and federal water and fisheries agency representatives formed a POD work team in 2005 to evaluate the potential causes of the decline. Many studies initiated by the POD work team and others are still in progress.

Central Valley salmonids have experienced significant declines while various pelagic species have continued to decline. Declines in pelagic and salmonid fish species have resulted in litigation, court-imposed requirements restricting water diversions, and additional Endangered Species Act (ESA) restrictions. In December of 2008, the U.S. Fish and Wildlife Service (USFWS) issued a revised biological opinion (BO) for delta smelt for operations of the State Water Project (SWP) and Central Valley Project (CVP) in the Delta. On December 11, 2008, National Marine Fisheries Service (NOAA Fisheries) issued its draft BO for Central Valley Chinook salmon and green sturgeon for the long-term SWP and CVP operations criteria and plan (OCAP). Following an extension of time, the final BO is expected by June 2009 and will supersede the 2004 OCAP BO.

Most recently, on March 4, 2009, the Fish and Game Commission voted unanimously to list the longfin smelt as a threatened species under the California Environmental Species Act (CESA) because longfin smelt abundance has declined substantially since the 1980s due to entrainment and loss at water diversions, increased salinity, loss of habitat, toxicity, predation by managed fishes, and other threats that could endanger its long-term survival and recovery in its native habitat and range. The commissioners also voted to list delta smelt as endangered, rather than a threatened species.

As a result of the fisheries decline in the estuary, multiple recovery plans have been initiated to help restore native fish species. The Anadromous Fish Restoration Program (AFRP) was tasked by the Central Valley Project Improvement Act (CVPIA) to make all reasonable efforts to at least double natural production of anadromous fish in California's Central Valley streams on a long-term, sustainable basis (USFWS 2001). The Resources Agency released a Pelagic Fish Action Plan in March 2007. This report builds on the Delta Smelt Action Plan, which was released in 2005. The Delta Smelt Action Plan (CA Resources Agency 2005) is a 14-point science-based framework to address declines in the Sacramento-San Joaquin Delta's native fish species, including the delta smelt. The Pelagic Fish Action Plan report was prepared in

response to a directive by the Legislature to the Natural Resources Agency to report on proposed actions to address the POD and stabilize the ecosystem in the Delta (CA Resources Agency 2007).

NOAA Fisheries prepared an outline to help facilitate the development of recovery plans for the evolutionarily significant units of Sacramento River winter-run Chinook salmon and Central Valley spring-run Chinook salmon and the distinct population segment of California Central Valley steelhead (NOAA Fisheries 2007). NOAA Fisheries has developed a Draft Recovery Plan for review, and plans to follow with a full public and peer review draft. The CALFED Science Program, Department of Fish and Game (DFG) and NOAA Fisheries have also worked on broader-scale restoration plans such as the CALFED Ecosystem Restoration Plan (ERP). A draft version of the ERP conservation strategy was made available in August 2008 (DFG 2008). The conservation strategy is currently being developed together with numerous other planning efforts for the Delta.

Climate Change

Climate change is already having an impact on all aspects of water management in the Bay-Delta system. Spring snowpack has decreased about 10 percent over the last century and sea level has risen about seven inches. The projected future effects of climate change on water supplies and water quality are numerous. Likely outcomes of climate change include continued sea level rise, more precipitation falling as rain, further reductions in snowpack, an earlier runoff season, increases in droughts and floods, increased water temperatures, and decreased water quality (DWR 2008a).

Increased sea water intrusion will result in decreased water quality in the Delta and will increase the need to release water from upstream reservoirs if freshwater conditions are to be maintained. Increasing severity and frequency of floods along with sea level rise will increase the risk of catastrophic levee failures and associated water quality and water supply impacts. Increasing temperatures and reduced inflow will increase stress on the ecosystem and put threatened and endangered species at greater risk. Improved scientific understanding of the effects of climate change will be needed to make appropriate and effective water management decisions.

The State and Regional Water Boards are committed to reducing the impact of climate change on the environment. In accordance with AB 32 (2006) and State Water Board Resolutions 2008-0011 (State Water Board 2008b) and 2008-0030 (State Water Board 2008c), climate change impacts and effects will be considered in basin planning and water right proceedings. In addition to considering the effects of changing climate on water supply and ecosystems identified above, the State Water Board will also consider opportunities to reduce greenhouse gas emissions through reduced energy use, enhancement of local water supplies, water conservation, storm water reuse, and recycling.

III. Water Quality Control Plan Review Process

Discussion

California Water Code section 13170 authorizes the State Water Board to adopt water quality control plans in accordance with the provisions of Water Code sections 13240 through 13244. Water quality control plans identify the beneficial uses of a water body, specify numeric or narrative water quality objectives to protect those beneficial uses and include a program of implementation for achieving the objectives (Wat. Code, § 13050, subd. (j)). Plans adopted by

the State Water Board supersede regional water quality control plans for the same waters to the extent of any conflict. The State Water Board's adoption of this Staff Report will mark the completion of the current periodic review. The State Water Board will then proceed with the process that may lead to a revised Plan or amendments to the Bay-Delta Plan.

The basin plan amendment process and potential amendment of water rights to implement the plan require preparation of environmental documentation in accordance with CEQA. Accordingly, the State Water Board will be the lead agency and will prepare environmental documentation for potential revisions to the Bay Delta Plan and its implementation. The proposed project under CEQA may include the review and potential amendment of water quality objectives, including flow objectives, and the program of implementation in the Bay-Delta Plan, as well as changes to water rights and water quality regulation consistent with the program of implementation.

The State Water Board intends to stage its environmental review of the Bay-Delta Plan and water rights implementation for this plan. The State Water Board will prepare a substitute environmental document for the water quality control plan components of the project that pertain to southern Delta salinity and San Joaquin River flows. The State Water Board anticipates preparing one or more EIRs to evaluate the environmental effects of any changes to water rights to implement the Bay-Delta Plan.

Public Notice

The State Water Board initiated its periodic review of the Bay-Delta Plan on August 29, 2008, by issuing a notice of a public workshop to receive comments on elements of the Bay-Delta Plan that may need amendment, new elements that should be added, or whether the entire plan should be revised. Because the State Water Board previously had committed to review the southern Delta salinity and San Joaquin River flow objectives, the notice informed the public that it did not need to address those issues in comments. The State Water Board accepted written comments through October 1, 2008, and held a public workshop on October 8, 2008.

Pursuant to a commitment included in the State Water Board's 2008 Bay-Delta Strategic Workplan, at the same time the State Water Board issued the notice for the periodic review, it made a request for written input on critical factual issues regarding the Bay-Delta's ecology and the impacts of water pollution and diversions. The purpose of the request was to solicit recommendations concerning the critical factual issues that the State Water Board should consider during proposed fact-finding proceedings on these issues. The information obtained from the fact-finding proceedings would then have been used to inform the State and Regional Water Boards' basin planning and environmental review activities and other State Water Board processes. However, after the close of the comment period on these factual issues, the State Water Board decided not to proceed with the fact-finding proceedings at that time. Comments received on the fact-finding issues, to the extent that they are relevant to the periodic review, are however discussed below and in Appendix A, "Responses to Comments."

Comments Received

The State Water Board received written comments in response to the periodic review notice discussed above, and oral comments at the periodic review workshop held on October 8, 2008, from the following organizations:

- The Bay Institute
- Central Delta Water Agency
- Central Valley Clean Water Association

- Community Clean Water Institute
- Department of Fish and Game
- Department of Water Resources
- The San Francisco Public Utilities Commission
- Stockton East Water District
- Northern California Water Association
- Sacramento Valley Water Districts
- San Joaquin River Group and San Joaquin River Group Authority
- San Luis & Delta-Mendota Water Authority and Westlands Water District
- South Delta Water Agency
- United States Department of the Interior

In addition to the periodic review comments, the State Water Board also received comments in response to the August 29, 2008 request for input on factual issues concerning the Bay-Delta from the following organizations:

- The Bay Institute
- California Farm Bureau Federation
- California Water Impact Network and California Sportfishing Protection Alliance
- Central Delta Water Agency
- Central Valley Clean Water Association
- City of Antioch
- Contra Costa Water District
- County of Sacramento & Sacramento County Water Agency
- Department of Fish and Game
- Department of Water Resources
- East Bay Municipal Utility District
- Northern California Water Association
- Sacramento Regional County Sanitation District
- San Joaquin River Exchange Contractors
- San Joaquin River Group
- San Luis & Delta-Mendota Water Authority, Westlands Water District, State Water Contractors & Kern County Water Agency
- South Delta Water Agency
- Stockton East Water District
- United States Department of the Interior

The periodic review notice, fact finding request, transcript from the October 8, 2008 workshop, and the written comments in response to the periodic review notice and the fact finding request are posted on the State Water Board's Division of Water Rights' website at: http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/periodic_review/index.shtml. In addition, Appendix A to this report includes a summary of the comments and responses to those comments as they apply to the periodic review of the Bay-Delta Plan.

Next Steps

Following adoption of the Staff Report, State Water Board staff will immediately begin a detailed review of the issues that the board has determined should receive further consideration. The State Water Board will hold one or more additional CEQA scoping meetings and basin planning workshops, and staff will review information received at those meetings, and other available scientific information, in order to develop recommendations for any needed changes to the Bay-Delta Plan. Staff will then prepare draft plan amendments or a draft revised plan for

consideration by the State Water Board and any required environmental documentation. Prior to certification of the environmental documentation and adoption of any revised Bay-Delta Plan, interested persons will have the opportunity, at a public hearing, to comment on staff's recommendations and on the environmental analysis. After the hearing, the State Water Board will hold a board meeting to consider adopting any proposed changes.

To avoid duplication of effort, to the extent feasible, the State Water Board will consider relevant analyses conducted for BDCP and other sources in its planning and environmental review efforts. When considering any other such analyses, however, the State Water Board will independently evaluate the information in the analyses. Any documents produced, or actions taken, by the State Water Board will reflect the independent judgment of the State Water Board.

IV. Issues

ISSUES THE STATE WATER BOARD HAS ALREADY COMMITTED TO REVIEW

Southern Delta Salinity and San Joaquin River Flows

In the State Water Board's 2008 Bay-Delta Strategic Workplan, the State Water Board committed to undertake a review of the southern Delta salinity and San Joaquin River flow objectives and their implementation. The State Water Board has already begun to evaluate these objectives through various processes. Accordingly, there is no need for a staff recommendation in this report. Nonetheless, this report includes a summary of these issues, as well as specific information regarding sources of salinity to the southern Delta, in order to provide an overview of the wide range of water quality issues that will, and should be, considered further in the basin planning process.

Evaluation of Southern Delta Salinity Objectives

The State Water Board established salinity objectives at four locations in the southern Delta as part of its 1978 Bay-Delta Plan. The southern Delta salinity objectives have remained unchanged since 1978. The State Water Board based these objectives on methodologies available at that time for estimating the maximum salinity of applied irrigation water that would sustain 100 percent yield of important salt sensitive crops grown in the southern Delta. The objectives were also based on the assumption that the Department of Water Resources (DWR) would install permanent operable barriers at four locations in the southern Delta. For numerous reasons these barriers have not been constructed, and their future is uncertain.

In the Bay-Delta Plan, the State Water Board determined that there was inadequate scientific information on which to base any changes at that time, but that additional information should be developed to determine what, if any, changes should be made to the southern Delta salinity objectives or their implementation to reasonably protect agricultural beneficial uses. In January 2007, the State Water Board held a workshop soliciting the latest scientific information and comments on the southern Delta salinity objectives from interested persons. Since then, State Water Board staff has contracted with a consultant specializing in agricultural water management to evaluate the latest scientific literature concerning factors related to crop salt tolerance and make recommendations regarding methodology for establishing salinity objectives appropriate for southern Delta agriculture. Staff is also working with DWR modelers to analyze water supplies needed to meet current salinity objectives through dilution. Staff held a Southern Delta Salinity Forum meeting in November 2008 on this work, and, later in 2009, intends to hold additional staff-level meetings to discuss the results of these analyses and other

information that may inform review of the southern Delta salinity objectives and their implementation. This process will be conducted in coordination with the Central Valley Water Board's establishment of standards and a Total Maximum Daily Load (TMDL) for salinity and boron in the lower San Joaquin River upstream of Vernalis, and integrated with CV-SALTS.

Sources of Salinity to Southern Delta

Agricultural beneficial use is negatively impacted if salinity concentrations in the surface waters of the southern Delta − the primary irrigation water supply for the agriculture beneficial use − exceed levels that could cause a reduction in crop yields. Identifying factors that increase salinity in the southern Delta is important for developing the implementation of salinity objectives established in the Bay-Delta Plan.

Salinity concentrations in the southern Delta are governed primarily by salinity in the San Joaquin River entering at Vernalis and by activities within the southern Delta, both of which are affected by a number of other factors as described below. The relative importance of these two factors is poorly understood at this time. Increased salinity in these areas is due to activities that either increase salt loads discharged in the watershed or otherwise act to accumulate or concentrate existing salts. Depending on SWP and CVP export operations, temporary barrier operations, and hydrologic conditions, there can also be occasional inputs of Sacramento River water to the southern Delta that may reduce salinity in the southern Delta (DWR 2006).

Source Loading & Evapo-Concentration

Factors controlling the loading and/or concentration of salts from various sources include:

- Salt loads resulting from seawater intrusion: DWR fingerprint modeling estimates that between August and December 2008 the percentage of salt present at Clifton Court Forebay (intake to the SWP) that originated from San Francisco Bay ranged between 33 percent and 43 percent (DWR 2008b). To the extent this water is entrained by the SWP pumps and is then transferred to the Delta Mendota Canal (DMC) as part of joint SWP and CVP operations, this salt from San Francisco Bay is effectively imported to the San Joaquin River.
- Salt loads to the San Joaquin River from surface agricultural discharges are estimated at between 410,000 and 540,000 tons of salt per year (Central Valley Water Board 2004a). These salts then reach the river either through direct discharge of return flows and tile drainage or accretions from shallow groundwater into which salts have percolated. Agricultural activity and water use both increase the load of salts and increase their concentration by:
    - Evapo-concentration of salt resulting from consumptive water use by crops (i.e. evapotranspiration).
    - Mobilization of naturally occurring salt otherwise bound in soils of marine origins, particularly on the west-side of the San Joaquin River (CALFED Bay Delta Program 2007).
    - Importation and distribution of salts contained in fertilizers and other soil amendments.
- Managed wetland operations concentrate and discharge salt delivered from a mix of CVP deliveries, groundwater, and agricultural tail water returns. Although limited data is available on wetland discharge water quality, mean net discharge from approximately

170,000 acres of wetlands in the San Joaquin River watershed is estimated at 101,000 tons per year (Central Valley Water Board 2004b).

- Industrial water use increases salinity concentrations in the watershed by both the addition of salts contained in raw material inputs and evapo-concentration of salts due to consumptive use. Industrial uses contributed an average of 38,000 tons per year to the San Joaquin River upstream of Vernalis between 1995 and 2002 (including salinity already in supply water). Depending on how a mass balance is calculated, a subtraction may be appropriate for salinity already contained (from other sources) in the industrial water supply. Industrial salt loads are either discharged directly, or via municipal collection and treatment systems, with approximately 40 percent being discharged directly to the San Joaquin River or its tributaries and the remainder discharged by land irrigation or processed through wetlands (Central Valley Water Board 2004a). Salt loads from industrial activities may also be mobilized to surface waters via stormwater runoff.
- Domestic water use is estimated to increase total dissolved solids concentrations (a measure of salinity) from 150 to 380 mg/L over and above the salinity of the water supply (Metcalf and Eddy 1991). This increase is attributable to a combination of imported salts (e.g. detergents, water softener salts) and evapo-concentration of salts due to consumptive use. Domestic water use contributed an average of 16,000 tons per year to the San Joaquin River upstream of Vernalis between 1995 and 2002 (including salinity already in supply water). Of domestic related salt loads discharged via municipal wastewater treatment plants, approximately 50 percent was discharged directly to the San Joaquin River, with the remainder discharged by land irrigation or processed through wetlands (Central Valley Water Board 2004a). Salt loads from domestic activities may also be mobilized to surface waters via stormwater runoff.

Flow Related Concentration Effects

The way flow is managed in the watershed leads to conditions that either result in accumulation of salt in soils and groundwater or otherwise have an effect on salinity concentrations in the San Joaquin River watershed and southern Delta.

- Under most hydrologic conditions, the CVP pumps near Tracy entrain much of the flow from the San Joaquin River at the head of Old River; the associated salt load is then re-circulated back to the river via the DMC, effectively trapping and accumulating salt within the watershed. Between 1977 and 1997 the DMC contributed approximately 513,000 tons or 47 percent of the total annual salt load in the San Joaquin River at Vernalis (Central Valley Water Board 2004b).
- Water exports out of the basin and diversions to storage from low salinity sources and subsequent consumptive use act to increase salinity concentrations in downstream surface waters of the watershed. For example, the export of Hetch-Hetchy water from the Tuolumne River removed from the San Joaquin River watershed an average of 250,000 acre-feet per year between 1985 and 1994, which is estimated to have increased salinity concentration in the San Joaquin River during that period from 506 microsiemens/cm (µS/cm equal to micromhos/cm) to 570 µS/cm (Central Valley Water Board 2006). Conversely, activities that provide relatively lower EC water to the river system (i.e. reservoir operations at certain times of the year) can result in lower salinity.
- Occasional inputs of Sacramento River water to the interior southern Delta can occur depending on Sacramento and San Joaquin River hydrology, SWP and CVP operations, and temporary barrier operations. DWR fingerprint modeling analysis shows these

inputs occur primarily at Old River near Tracy, and Old River near Middle River. When these inputs occur there is typically a corresponding decrease in salinity concentrations at those same locations (DWR 2006).

The averaging periods and temporal occurrence of the above loading information varies. Therefore it is not intended to be provided for direct comparison, but rather to demonstrate the relative effect of each factor. Better information and analysis regarding the above conditions will be needed to develop a comprehensive salt balance for the southern Delta. Such analyses will inform development of a program of implementation for salinity objectives in any updates to the Bay-Delta Plan.

Evaluation of San Joaquin River Flow Objectives

San Joaquin River flow objectives were first established at Vernalis in the 1995 Bay-Delta Plan to protect fish and wildlife beneficial uses. The State Water Board set different objectives for three time periods: February through June, excluding April 15 through May 15 (spring flows); April 15 through May 15 (pulse flows); and October (fall flows). The spring flows are intended to provide minimum net downstream freshwater flows in the San Joaquin River to address habitat concerns from reduced flows and water quality. The pulse flows were principally developed to aid in cueing Chinook salmon smolt out-migration from the San Joaquin River. The fall flows were developed to provide attraction flows for adult salmon returning to the watershed to spawn. These objectives were based on the limited scientific information available at the time. As a result, in order to obtain additional scientific information, in D-1641, the State Water Board approved conducting the Vernalis Adaptive Management Plan (VAMP) experiment proposed in the San Joaquin River Agreement (SJRA), in lieu of meeting the pulse flow objectives included in the 1995 Plan, until 2012.

The San Joaquin River flow objectives were unchanged in the Bay-Delta Plan due to insufficient scientific information on which to base any changes at the time. The program of implementation, however, was amended to allow the VAMP experiment to be conducted in lieu of the pulse flows. In addition, the State Water Board concluded that additional scientific information should be developed to determine what, if any, changes should be made to the objectives or their implementation to reasonably protect fish and wildlife beneficial uses. In order to gather this information, the State Water Board conducted a workshop in September of 2008 to receive additional information including an update on the salmon escapement model for the San Joaquin River that the California Department of Fish and Game (DFG) developed as a tool for developing revised flow objectives. The State Water Board also requested that the San Joaquin River Group Authority (SJRGA) conduct a peer review of the VAMP to determine whether changes may be needed to the study to obtain necessary data points and to ensure the protection of San Joaquin River and Delta species. The State Water Board intends to hold additional staff-level meetings later this year to obtain additional information concerning the San Joaquin River flow objectives and their implementation.

ADDITIONAL ISSUES IDENTIFIED FOR FURTHER REVIEW

Delta Outflow Objectives

Issue: Delta outflow and/or inflow objectives for the protection of fish and wildlife beneficial uses.

Staff Recommendation: Staff recommends that the State Water Board consider changes to the Delta outflow objective, or alternatively Delta inflow from the Sacramento Basin, based on available information as part of its review and possible revision of the Bay-Delta Plan.

Discussion: The Delta outflow objective is intended to protect estuarine habitat for anadromous fish and other estuarine dependent species. Delta outflows affect migration patterns of both estuarine and anadromous species and the availability of habitat (State Water Board 1999). Freshwater flow is an important cue for upstream migration of adult salmon and is a significant factor in the survival of smolts moving downstream through the Delta. The populations of several estuarine-dependent species of fish and shrimp vary positively with flow as do other measures of the health of the estuarine ecosystem (Kimmerer 2004). Freshwater inflow also has chemical and biological consequences through its effects on loading of nutrients and organic matter, pollutant concentrations, and residence time.

The Delta outflow objective includes requirements for calculated minimum net flows from the Delta to Suisun and San Francisco Bays (the Net Delta Outflow Index or NDOI) and maximum salinity requirements (measured as electrical conductivity or EC). Since salinity in the Bay-Delta system is closely related to freshwater outflow, both types of objectives are indicators of the extent and location of low salinity estuarine habitat. Listed in Table 3 of the Bay-Delta Plan, the Delta outflow objective varies by month and water year type. With some flexibility provided through a limited set of compliance alternatives, the basic outflow objective sets minimum outflow requirements that apply year round.

In addition to the basic outflow objective, Table 4 of the Bay-Delta Plan includes a set of salinity requirements that apply from February through June, often referred to as the X2 objectives. X2 is defined as the distance in kilometers from the Golden Gate Bridge of the 2 parts per thousand (ppt) isohaline at a depth of one meter from the bottom of the channel, which is approximately equivalent to a surface EC of 2.64 millimhos/cm (mmhos/cm). The X2 objectives are designed to restore a more natural hydrograph and salinity pattern by requiring maintenance of the low salinity zone at a specified point and duration based on unimpaired flow conditions. The X2 objectives are based on the concept of “X2 days”: the number of days in a month that the objective must be met at a specified location through any one of three alternatives. The alternatives for meeting the X2 objective on any given day include meeting the maximum daily average EC requirement (2.64 mmhos/cm), the 14-day running average maximum EC, or the specified 3-day average NDOI requirement for the specified location. As with the Delta outflow objective in Table 3, Table 4 includes compliance alternatives that can provide some operational flexibility in meeting the objectives.

Several species of fish that depend on the Delta have experienced significant declines in recent years. There is evidence that these declines are due in part to the impact of SWP and CVP operations (Baxter et al. 2008, NOAA Fisheries 2008). As indicated previously, since 2002, the abundance of four species of pelagic fish, including delta smelt, have declined dramatically (Sommer et al. 2007). Decline of these four pelagic species has been accompanied by declines in other fish species and has raised concerns about the ecological health of the estuary (Feyrer et al. 2007, Baxter et al. 2008, Lund et al. 2008, Nobriga et al. 2008). Understanding of the factors contributing to the POD and the health of the Delta ecosystem has improved since the last review of the Bay-Delta Plan and continues to expand with ongoing research.

Monitoring of fish and invertebrate abundance in the estuary continues to show the importance of flow. The relationships between outflow and several measures of the health of Bay-Delta estuary have been known for some time (Jassby 1995) and are the basis for the current X2

objectives. A more recent study determined that updated abundance-X2 relationships were similar to those previously reported and are seen in a wide variety of estuarine fish species (Kimmerer et al. 2009). Abundance of the upper estuary shrimp, *Crangon franciscorum,* an important invertebrate species in the Bay-Delta ecosystem, is also strongly correlated with flow (IEP 2008). Stream flow and Delta outflow are also important factors in the survival of Chinook salmon (NOAA Fisheries 2008).

With respect to delta smelt, outflow probably has two distinct but related impacts. Low outflow shifts the preferred habitat for many of the POD species closer to the area influenced by the SWP and CVP export facilities, thereby contributing to entrainment. Low outflow also decreases the extent and quality of delta smelt habitat (Baxter et al. 2008). Water temperature, salinity, and clarity have been shown to influence the distribution of delta smelt, and suitable summertime physical habitat for this species has likely decreased over time (Nobriga et al. 2008). Water temperature and salinity are directly related to outflow.

A PPIC report hypothesizes that increased variability in Delta geometry would lead to more variability in residence time and other habitat parameters, which in turn would be more favorable to desirable species (Lund et al. 2007). The concept of habitat variability includes the hypothesis that more seasonal and year-to-year variability in salinity could be beneficial for native estuarine species (and striped bass) and less favorable for undesirable introduced species. A CALFED workshop explored these concepts and generally concluded that the evidence supporting the benefits of variable salinity was mixed; that habitat variability needs to include more than just salinity, and additional study at multiple scales is needed to test these ideas (CALFED Science Program 2007). The concept of a Delta with more diverse habitats, flows, and salinity, and the potential ecosystem benefits of these, has been explored further using available data and computer modeling (Lund et al. 2008). A Delta with greater habitat variability, variability in tidal and riverine flows, variability in water chemistry (especially salinity), over multiple scales of time and space, would likely support greater populations of desirable fish species (Moyle et al. 2009 in prep). The benefits of habitat variability (including flow and salinity variability), and provisions for testing and monitoring these hypotheses should be considered during development of any new or modified outflow objectives.

In its BO on the effects of SWP and CVP operations on delta smelt, the USFWS agrees with the studies that show, in addition to entrainment, the amount and quality of habitat are important factors in the survival of smelt, particularly in the fall. For much of their life cycle, the preferred habitat for delta smelt is the low-salinity zone (indicated by the position of X2). The location, lateral extent, and quality of this habitat depend on outflow but it is usually centered somewhere in the western Delta or Suisun Bay. The BO for delta smelt on operations of the SWP and CVP in the Delta finds that outflow over and above that required by the Bay-Delta Plan is needed to insure the survival of the species. Specifically, the BO calls for meeting X2 objectives during September and October following wet and above normal water years, and the release of November Sacramento basin reservoir inflows to provide more Delta outflow in the fall (USFWS 2008).

The effects of Delta outflow objectives on other species, regions, and water uses must also be considered. In addition to reduced supplies available for municipal/industrial and agricultural uses, existing and any increased outflow requirements could reduce the amount of cold water available in SWP and CVP reservoirs available for temperature control (the coldwater pool). In particular, revisions to the existing outflow objectives should consider potential impacts on flow and temperature control affecting salmonids upstream (NOAA Fisheries 2008). For this reason,

the State Water Board could decide to also review Delta inflow from the Sacramento Basin as part of its review of Delta outflow objectives.

Conclusion: The available information indicates that further review and change of Delta outflow objectives may be required. Changes to Delta outflow patterns have likely contributed to the POD and are likely having an impact on the abundance of other species of concern. Actions taken under the federal ESA are already changing outflow requirements for the SWP and CVP and additional species protection actions are imminent. Additional Delta outflow recommendations are likely to come from the BDCP and other planning efforts currently under way. Based on current scientific information, recent regulatory actions, and expected recommendations from agencies and stakeholder groups, staff recommends the State Water Board conduct a detailed review of the Delta outflow objectives for possible revisions to the Bay-Delta Plan. Any revisions should also consider the need for Delta inflows. Some of this review could be provided by DWR to the State Water Board, in coordination with State Water Board planning efforts, as part of the environmental analyses conducted for the BDCP.

Export/Inflow Objectives

Issue: Export Limits for the Protection of Fish and Wildlife Beneficial Uses

Staff Recommendation: Staff recommends that the State Water Board consider changes to export limits based on available information as part of its review and possible revision of the Bay-Delta Plan.

Discussion: The objective for export limits in the Bay-Delta Plan protect fish and wildlife beneficial uses, including the habitat of estuarine-dependent species, in part by reducing the entrainment of various life stages by the major export pumps in the southern Delta.

The export limits (also known as the ratio of exports to inflow or E/I ratio) limit the combined amount of water that may be exported from the Delta by the SWP and CVP water project facilities in the southern Delta relative to total Delta inflow. The limit is 35 to 45 percent of Delta inflow for February (depending on total inflow conditions during January), 35 percent from March through June, and 65 percent of Delta inflow from July through January. Additional limits of 1,500 cfs or 100 percent of San Joaquin River flow apply from April 15 through May 15 (spring pulse flow period). These spring flow limits may be adjusted upon the agreement of the fishery agencies and upon notice to the Executive Director of the State Water Board. The spring flow limit specifies that flexibility in allowing variations in the maximum export rate be intended to result in no net annual loss of water supply within the water quality and operational requirements of the plan.

The spring flow period export limit restricts the combined pumping at the SWP and CVP Delta pumping facilities to 1,500 cfs or the measured flow of the San Joaquin River at Vernalis, whichever is greater. During the spring pulse flow period export limits generally reduce the amount of pumping at the SWP and CVP Delta pumping facilities in concert with increasing San Joaquin River flow meant to improve survival of downstream migrating juvenile salmon. For the remainder of the year, the percent of allowable inflow diverted is calculated using a formula that divides SWP and CVP Delta pumping by the sum of Delta inflows. The 35 percent (and up to 45 percent in February) limit reduces pumping from February through June to protect a variety of fish species that use the Delta for spawning, rearing, and migration during the spring months (State Water Board 2006). The 65 percent limit during the remainder of the year (primarily

summer and fall) is important for maintenance of habitat conditions for estuarine-dependent species in the western Delta and downstream in Suisun Bay (State Water Board 1995).

The impacts of SWP and CVP pumping on Delta fish species and other biota have long been recognized. The environmental analysis conducted with the 1995 Bay-Delta Plan identified the benefits of the export limits, including the spring pulse flow objective, to salmon, striped bass, delta smelt, splittail, and other estuarine species. The spring E/I ratio of 35 to 45 percent was designed to reduce the risk of entrainment of eggs, larvae, and fish when they are most likely to be present in the Delta (State Water Board 1995). Further environmental analysis conducted for the 1995 Bay-Delta Plan determined that, through entrainment, SWP and CVP export pumping also reduced the amount of fish food organisms (phytoplankton and zooplankton) available in the Delta. The analysis also identified the relationship between export limits and reverse flows in southern Delta channels and their significance to the biological impacts of SWP and CVP pumping (State Water Board 1999).

Recent studies provide additional evidence of the likely role of SWP and CVP export pumping in the continued decline of several Delta fish species. The POD, first identified in 2002, has been the subject of intensive study, legal actions, and regulatory changes and a catalyst for more intensive study of physical and biological processes related to the Delta. A comprehensive overview of open water processes in the Delta found that export pumping may have a considerable cumulative effect on fish and other relatively slow growing biota (Kimmerer 2004). This study also found that losses of larval fish are roughly proportional to the fraction of Delta volume diverted. In its most recent annual POD synthesis report, the IEP found that winter losses at the SWP and CVP export facilities of adult delta smelt, longfin smelt, and threadfin shad (three important pelagic fishes in the Delta) may be an important factor related to the overall decline of these species (Baxter et al. 2008a). The POD synthesis report also identifies the potential use of reduced reverse flows in Old and Middle Rivers near the SWP and CVP export facilities as one method of decreasing winter entrainment of adult delta smelt. More recently, estimates of the population of delta smelt and losses at the SWP and CVP southern Delta export facilities indicate that a significant fraction of the population may be lost due to export pumping (Kimmerer 2008). Additional analyses by Kimmerer and Nobriga in 2008, using the particle tracking component of the Delta Simulation Model 2 (DSM2) to simulate movement of larval Delta smelt, found that losses to the pumps could be substantial. This study also found that the E/I ratio is a useful predictor of entrainment.

As one of several objectives for Delta flow, the export limits work in concert with outflow, river flow, and water quality objectives to govern storage, release, and pumping operations of the SWP and CVP export facilities both within and upstream of the Delta. Several studies have noted the relationship between Delta outflow, E/I ratio and entrainment of fish and other biota. Higher flows combined with reduced exports are designed to reduce salmon mortality during the spring pulse flow period by speeding passage through the Delta and reducing the risk of entrainment at the pumps (State Water Board 1995). Conversely, lower outflows can shift the distribution of delta smelt and other fish species (including salmon) closer to the pumps and, combined with reverse flows in Old and Middle Rivers, increase the risk of entrainment at the SWP and CVP export facilities (IEP 1996, State Water Board 1999). The recent USFWS BO for delta smelt finds that predicted entrainment depends on both outflow (as measured by X2) and reverse flows in Old and Middle Rivers (USFWS 2008).

Information indicating that the populations of several key Delta fish species remain at dangerously low levels has continued to emerge since adoption of the 2006 Bay-Delta Plan. Recent studies indicate that although there are multiple causes, export pumping remains a likely

factor in the decline of several pelagic fish species in the Delta (Baxter et al. 2008a). Various entities have suggested measures to address the issue. For example, in its Delta Vision Strategic Plan, the Governor's Task Force recommended that the State Water Board revise the export criteria applicable to the SWP and CVP water projects (Delta Vision 2008). The 2008 PPIC report on the future of the Delta suggests that reducing or ending the use of the southern Delta pumps may prevent fish entrainment and altered flows harmful to fish (Lund et al. 2008). In 2007 the federal district court imposed an interim order reducing SWP and CVP pumping to protect Delta smelt (Wanger 2007). The USFWS BO on delta smelt (USFWS 2008) requires new actions related to flow for the protection of delta smelt (see reverse flows section). Conservation measures currently under consideration in the BDCP process will likely require additional modifications to operating criteria for a number of existing and planned facilities. These changes may require re-evaluation of the export limit objectives as well as other Delta flow objectives in the Bay-Delta Plan (BDCP 2008).

In addition to reducing entrainment, the existing export limits are intended to provide general protection of the Delta ecosystem and a variety of fish and wildlife beneficial uses by limiting the portion of freshwater that may be diverted by the SWP and CVP export facilities. Additional ecosystem benefits beyond reducing entrainment may include reduction in losses of nutrients and other materials important for the base of the food web, food organisms, habitat suitability, fishery management, and more natural flow and salinity patterns.

Conclusion: The available information indicates that new or changed export limits may be necessary to adequately protect beneficial uses in the Delta. Recent analyses of the impact of export pumping on Delta fish species of concern show that more restrictive limits may be required. The export limits are closely related to reverse flow limitations described in the recent delta smelt BO. Staff recommends that the State Water Board evaluate the possible modification of the export limits objectives in the Bay-Delta Plan based on current scientific information concerning pelagic organisms, salmonids, other species, and other appropriate information. This review will likely require an assessment of issues associated with exports that may arise in connection with proposals in the BDCP process to modify existing diversions or construct new diversions. Some of this review could be provided by DWR to the State Water Board, in coordination with State Water Board planning efforts, as part of the environmental analyses conducted for the BDCP.

Delta Cross Channel Gate Closure Objectives

Issue: Delta Cross Channel Gate objective for the protection of fish and wildlife beneficial uses in the Bay-Delta

Staff Recommendation: Staff recommends that the State Water Board consider changes to the Delta Cross Channel (DCC) gate objective based on available information as part of its review and possible revision of the Bay-Delta Plan.

Discussion: The DCC gate is located near Walnut Grove and at times allows for the transport of up to 3,500 cfs of water from the Sacramento River to Snodgrass Slough and the North Fork Mokelumne River to the interior Delta. The DCC was constructed in the early 1950s to convey Sacramento River water to the interior and southern Delta to improve water quality at the SWP and CVP export facilities. The DCC also benefits recreational uses by providing boat passage.

The DCC gate objective was designed to protect fish and wildlife beneficial uses (specifically Chinook salmon) while simultaneously recognizing the need for fresh water to be moved

through the interior Delta to the southern Delta for SWP and CVP uses. The current objective states that the DCC gate shall be closed for a total of up to 45 days for the November through January period, stay closed from February through May 20, and be closed for a total of 14 days for the May 21 through June 15 period. The United States Bureau of Reclamation (USBR) is required to determine the timing of gate closures after consultation with NOAA Fisheries, USFWS, and DFG. As the owner and operator of the DCC gate, USBR is required to meet the DCC objective. In addition, USBR closes the DCC gate for flood control purposes when flows are high on the Sacramento River (greater than 20,000 to 25,000 cfs) to avoid channel scouring within the interior Delta.

Closure of the DCC gates is important for the protection of salmon survival. Opening the DCC gates during winter and spring months can negatively affect juvenile Chinook salmon survival by causing straying into the interior and then southern Delta (Brandes and McLain 2001). The proportion of the juvenile winter-run Chinook salmon population lost at the SWP and CVP export facilities each year has been found to be correlated to the proportion of Sacramento River flow diverted through the DCC during the time juvenile winter-run Chinook are emigrating through the lower Sacramento River in the vicinity of the DCC and Georgiana Slough (Low and White 2006).

Opening the DCC gate significantly improves water quality (e.g. lowers salinity) at the SWP and CVP export facilities, particularly in the fall when Delta outflow is low. A CALFED assessment of the sources and causes of salinity at the Banks and Tracy pumping plants reinforced the association of DCC gate closure with increased intake EC (CALFED Bay-Delta Program 2007).

During the periodic review and plan review resulting in the current Bay-Delta Plan, amendment to the DCC gate objective was considered, but at that time the State Water Board determined that it had not received adequate information to support amending the DCC gate objective. Since the adoption of the Bay-Delta Plan, additional information has become available and studies have been completed or are in process.

The most recent studies indicate that greater than 69 percent of out-migrating salmon move at night (Perry and Skalski 2008). This study suggests that closing the DCC gate only at night should result in similar fish protection as 24-hour closure, while improving water quality at the pumps. In the ongoing North Delta Salmon Outmigration Study led by Jon Burau, preliminary results show that less than ten percent of juveniles enter the DCC when the gate is open during the day only (Burau 2008 draft results). Data from such studies will improve the understanding of route selection and survival of the Sacramento River juvenile Chinook salmon in the Sacramento/San Joaquin Delta with respect to DCC gate operations. These studies will help provide management tools capable of predicting impacts on salmon out-migrants considering operations of existing facilities in the Delta, such as the DCC, and proposed conveyance alternatives (USGS 2008). Staff recommends reviewing these studies and other information when considering any changes to the DCC gate objective, especially with respect to partial day closures or modification to timing and duration of gate closures.

NOAA Fisheries is under court order to complete a revised OCAP BO for listed salmonids (which includes steelhead) and green sturgeon, now expected in June 2009. A preliminary draft of the BO includes prescriptive closure of the DCC gate beginning on December 15 and ending on January 15. Additional requirements for DCC gate operations may also be included in the BO. The BDCP process has reviewed operations of the DCC gate and is also developing recommendations that may include additional closure of the gate.

Conclusion: The DCC gate, if opened, can negatively impact fish and wildlife beneficial uses. Opening the gate, however, can benefit municipal, industrial, and agricultural beneficial uses. Updated information, including studies regarding partial gate closures and potentially new requirements from the NOAA Fisheries OCAP BO for salmonids and green sturgeon should be available during the basin plan amendment process. Additionally, BDCP is reviewing DCC gate operations for potential modification. Given likely availability of new information and the importance of the DCC gate to overall Delta water quality conditions, staff recommends the State Water Board review the DCC gate objective in the Bay Delta Plan. Some of this review could be provided by DWR to the State Water Board, in coordination with State Water Board planning efforts, as part of the environmental analyses conducted for the BDCP.

Suisun Marsh Objectives

Issue: Suisun Marsh water quality objectives for the protection of fish and wildlife beneficial uses in the Bay-Delta.

Staff Recommendation: Staff recommends that the State Water Board consider changes to the water quality objectives that apply to the Suisun Marsh region as part of its review and potential revision of the Bay-Delta Plan.

Discussion: Suisun Marsh is the largest contiguous brackish wetland in the western US, situated between the fresh water Delta ecosystem and the saline ecosystem of San Francisco Bay. Suisun Marsh, which includes a combination of tidal wetlands, diked seasonal freshwater and brackish water wetlands, sloughs, and upland grasslands, represents about 10 percent of California's remaining wetlands. These wetlands provide many important ecological functions, including wintering and nesting area for waterfowl and water birds of the Pacific Flyway, nursery habitat for native fish, and essential habitat for other fish, wildlife, and plants, including several threatened, endangered, or sensitive species (e.g. Delta smelt, splittail, and the salt marsh harvest mouse). Many of these species are dependent upon specific estuarine conditions for their survival.

As a result of Suisun Marsh's location in the Bay-Delta, water quality in the marsh affects, and is affected by, the SWP and CVP export facilities, and other upstream diversions. The aquatic habitat of Suisun Marsh continues to be under significant pressure from a variety of stressors including the effects of water diversions, pollutants, invasive species, and climate change (DWR 2007, Moyle and Bennett 2008, O'Rear and Moyle 2008). These factors have made Suisun Marsh one of the most highly regulated wildlife habitat areas in California. Protecting, restoring, and enhancing beneficial uses in and around Suisun Marsh is important, especially given recent declines in species listed under endangered species laws.

In 1988, construction and operation of physical facilities to control channel water salinity were completed, including the Suisun Marsh Salinity Control Gate. The gate is located in Montezuma Slough just downstream of the confluence of the Sacramento and San Joaquin rivers. The gate is left open when water flowing out of the Delta is fresh (generally in winter) and is operated (closed) with the tides during times when saltier water moves back up the Bay (generally in summer and fall) (The Center for Land Use Interpretation 2009). The gate uses tidal pumping to push fresher water into the marsh by opening to let Delta water flow in with the outgoing tide and closing during the incoming tide which tends to push saltier water out of the marsh. Operation of the gates, however, can move the position of X2 upstream (IEP 2001). Delta outflow is the primary source of fresh water for Suisun Bay and Suisun Marsh and limits the intrusion of saline ocean water into the marsh.

The Suisun Marsh salinity objectives were first adopted in the State Water Board's 1978 Bay-Delta Plan. The DWR and USBR were assigned responsibility for meeting the objectives in State Water Board Decision 1485 (D-1485). In the 1995 Bay-Delta Plan, the State Water Board amended the salinity objectives included in the 1978 Bay-Delta Plan. The 1995 Bay-Delta Plan lists numeric salinity objectives at seven locations within the Marsh and includes a narrative objective for the brackish tidal marsh areas.

The purpose of the Suisun Marsh numeric salinity objectives is to provide water of sufficient quality to the managed wetlands to achieve soil water salinities capable of supporting the plants characteristic of a brackish marsh. The D-1485 objectives were based on research that investigated the salinity tolerance of alkali bulrush (*Scirpus maritimus*) and other important waterfowl food plants in the Suisun Marsh. The research identified the maximum mean applied water salinity that would provide an average of 90 percent of the maximum alkali bulrush seed production and a 60 percent seed germination rate. At that time, the D-1485 salinity objectives were thought to represent the most saline water that can be applied regularly to well-managed wetlands without loss of alkali bulrush seed production (State Water Board 1995; State Water Board 2000). The range of brackish water for Suisun Marsh, as defined by the 1995 Bay-Delta Plan objectives is 8-19 mmhos/cm.

In the 1995 Bay-Delta Plan Program of Implementation, the State Water Board called for the convening of an ecological work group to reassess the water quality objectives in Suisun Marsh. As a result, the Suisun Ecological Workgroup (SEW) was convened as a Project Work Team under the IEP. The SEW is composed of representatives from DWR, DFG, USBR, USFWS, Suisun Resource Conservation District, and State Water Board. Among several goals of the SEW are: evaluate the beneficial uses and water quality objectives for the Suisun Bay and Suisun Marsh ecosystem; identify specific measures to implement the narrative objective for tidal brackish marshes of Suisun Bay; and make recommendations to the State Water Board regarding achievement of the objective and development of numeric objectives to replace it.

In response to the recommendations contained in the 1995 Bay-Delta Plan, the SEW submitted a final report in 2001 summarizing nearly four years of technical research and discussions, with a range of ecological perspectives, goals, and views. The recommendations were based on conceptual models detailing the ecological relationships between the physical, chemical, and biological factors affecting the health of the resource (e.g. salinity level, habitat availability). Recommendations included, but were not limited to: maintaining Suisun Marsh salinity standards as written in the 1995 Bay-Delta Plan, revising the narrative standard, and establishing new flow-based salinity standards (IEP 2001).

In 2001, after the CALFED Record of Decision (ROD) was issued, the interagency Suisun Marsh Charter Group (SMCG) was formed to develop the Suisun Marsh Plan. The Suisun Marsh Plan is intended to provide a long term plan for tidal marsh restoration and managed marsh enhancements to balance threatened and endangered species recovery with maintenance of existing land and water use practices in the marsh (SMCG 2004b). The SMCG has begun developing a programmatic EIS/EIR for the Suisun Marsh Plan. A public draft is expected in mid 2009, with a final EIS/EIR in early 2010. The SMCG has committed to providing a proposed plan for potential changes to the water quality objectives following completion of the EIS/EIR. State Water Board staff will consider the Suisun Marsh Plan during review of the objectives for the Suisun Marsh region.

In addition to efforts by the SEW and the SMCG, the BDCP is currently looking into restoration activities in Suisun Marsh as part of its larger plan for Bay-Delta ecosystem restoration. The State Water Board will consider all of these investigations, discussions, and recommendations in any review of the objectives.

Conclusion: The available information indicates that possible changes in Suisun Marsh objectives should be investigated. Suisun Marsh provides important habitat for nesting waterfowl, juvenile fish, and other fish, wildlife, and plants, including several threatened, endangered, and sensitive species. These essential ecological functions are under significant pressure from a variety of stressors, including the effects of water diversions, pollutants, invasive species, and climate change. Staff recommends that the State Water Board review the Suisun Marsh objectives as part of its potential revisions to the Bay-Delta Plan.

Reverse Flow Objectives (Old and Middle River Flow Objectives)

Issue: Reverse flows in Old River and Middle River in the southern Delta

Staff Recommendation: Staff Recommends that the State Water Board evaluate establishment of Old River and Middle River flow objectives as part of its update of the Bay-Delta Plan.

Discussion: The Bay-Delta Plan currently includes flow-based objectives for the protection of fish and wildlife beneficial uses including a Delta outflow objective, river flow objectives, and export limits. In light of the continued fishery declines in the Bay-Delta, however, the State Water Board should consider adopting flow objectives for Old and Middle Rivers to protect estuarine dependent fish species.

The continued decline in the populations of several Delta fish species, as indicated by reductions in survey indices (Armor et al. 2007), also suggests that the export limits in the Bay-Delta Plan are not sufficient to protect aquatic species. Although other potential contributing causes to the fishery decline have been identified (toxic substances, invasive species, temperature, and other factors), SWP and CVP exports have been identified as a major contributing factor in the decline of Delta smelt and other pelagic species (Jassby 2005, Kimmerer 2002 and 2008). Diversions in the southern Delta, particularly the large SWP and CVP export facilities, can cause the net flow in nearby reaches of Old and Middle Rivers to reverse from the natural northward direction and flow south towards the SWP and CVP pumps. These “reverse flows” can draw fish, especially the weaker swimming young of pelagic species, into the SWP and CVP export facilities where there can be significant mortality.

The effects of reverse flows in Old River and Middle River in the south Delta have been addressed in both judicial and regulatory venues. In May 2007, Judge Oliver Wanger of the United States District Court ruled that reverse flows in Old River and Middle River were caused by diversions from the SWP and CVP and have contributed to the decline of Delta smelt. He issued an interim remedial order in December 2007 that among other things required seasonal reverse flow restrictions in Old and Middle rivers in the Delta (Wanger 2007). This order effectively required the Banks and Jones facilities to reduce pumping in winter and spring to protect various life stages of Delta smelt. The interim order also directed the USFWS to prepare a revised BO for protection of Delta smelt that applies to operations of the SWP and CVP. The Delta smelt BO was transmitted to the Court on December 15, 2008 and contains restrictions on Old and Middle River flows that are very similar to those in the interim order (USFWS 2008).

The purpose of the export limits contained in the Bay-Delta Plan (see the previous discussion on E/I Ratio) is similar in intent to the Old and Middle River flow restrictions imposed by Judge Wanger, and contained in the 2008 Delta smelt BO. Both are primarily intended to reduce the impact of the SWP and CVP export facilities on fish and other aquatic species.

The existing export limit objectives and the Old and Middle River flow constraints prescribed in the Wanger decision and the Delta smelt BO differ in one key technical respect. The export limits are generally expressed as a percentage of total Delta inflow (except during the spring VAMP flow period). The Wanger and BO Old and Middle River flow limits are in terms of net flow based on continuous direct measurements of flows in these rivers adjusted to account for the tidal movement of water. These different approaches to reducing the impact of SWP and CVP export facilities on aquatic life will need to be considered in the water quality control planning process.

Conclusion: The most recent analyses of the impacts of south Delta diversions on fish and other aquatic species indicate that Old and Middle River flow restrictions are potentially an effective way to reduce the entrainment impacts of the south Delta SWP and CVP export facilities. Staff recommends that the State Water Board consider and evaluate the merits of adding Old and Middle River flow objectives to the Bay-Delta Plan. Some of this review could be provided by DWR to the State Water Board, in coordination with State Water Board planning efforts, as part of the environmental analyses conducted for the BDCP.

Floodplain Habitat Flow Objectives

Issue: Flow objectives to support floodplain habitat and other fish and wildlife beneficial uses.

Staff Recommendation: Staff recommends that the State Water Board investigate establishing water quality standards for flow or other flow-related requirements to support inundated floodplain habitat in the Bay-Delta watershed as part of the update of the Bay-Delta Plan. Establishing any standards would require careful evaluation of potential impacts to beneficial uses, water quality effects, and other concerns such as water availability and fish passage (in coordination with the Regional Water Quality Control Boards, fisheries agencies, flood control authorities and other appropriate groups). Staff also recommends that the State Water Board work closely with the BDCP parties during development of any standards or related requirements.

Discussion: The Bay-Delta is the largest estuary and among the most biologically important ecosystems on the West Coast. Dams, extensive levee systems, and other riverine alterations, however, have reduced floodplain habitat and resulted in extreme losses of aquatic-dependent and terrestrial species (Moyle et al. 2007). Flood management in the Delta has severed nearly 297,000 acres (460 square miles) of historic Central Valley floodplains from their parent rivers and streams (Healy et al. 2008). Viers et al. (2007) from the Cosumnes Research Group estimated that less than 5 percent of the Central Valley's original riparian forest remains intact. Levees now impede periodic flooding of areas that previously provided valuable habitat and food supply for fish and other organisms. Levees also block the distribution of receding waters rich in nutrients, sediment, and organic materials that can help support biological productivity in the Bay-Delta estuary (Healey and Mount 2007). Important geomorphic, hydrologic, and ecological functions and values provided by floodplains in the Delta, including the capacity to sustain viable populations of native and desired species, have been fundamentally changed and degraded, and continue to decline (Okamot 2000).

Properly managed floodplains have the potential to provide widespread benefits at multiple levels ranging from individual organisms to ecosystems (Feyrer et al. 2006). Floodplain inundation substantially increases the total availability of shallow water habitat consisting of a wide range of substrate types and low velocities that are suitable for spawning and rearing of native and desired fishes, including splittail and Chinook salmon (Sommer et al. 2001a, Sommer et al. 2004). Splittail are frequently found in flooded areas because they require flooded vegetation for spawning and rearing (USFWS 2003). The Yolo and Sutter bypasses and the Cosumnes River floodplain, for example, serve as important splittail spawning and early rearing habitat (Sommer et al. 1997).

Floodplain habitats are important to Chinook salmon because they provide rearing habitat, provide increased foraging opportunities and reduce energy expenditure (Sommer et al. 2001a, Sommer et al. 2005). Opperman (2006) found that floodplain habitat promotes rapid growth and increases survival of juvenile Chinook salmon. Recent studies hypothesize that fish migrating to and through the Delta may be protected from various risks, including major water diversions, by using the Delta's primary floodplain, the Yolo Bypass (Sommer et al. 2001a, USFWS 2003).

Seasonal flooding creates river-floodplain connectivity, allowing a diverse mixture of flood-dependent species, including pisciverous birds and mammals, bats, and insects to co-exist (Brown 1997). Following flood events, nutrient-rich litter from adjacent forested areas support insect populations, thereby providing an important winter source of food for large numbers of migratory birds and waterfowl on the Pacific Flyway (Nichols et al. 1986, Sommer et al. 2003). Flood-dependent native plant and invertebrate species require hydrologic variability for propagation and reproduction (Feyrer et al. 2006, Opperman 2008). A study in the Yolo Bypass, for example, found that a newly identified midge, *Hydrobaenus saetheri*, rapidly develops once dried floodplain sediments are rehydrated (Benigno and Sommer 2008). Native fish species such as splittail and salmon are adapted to seasonal flooding during winter and early spring and thus are favored over non-native species, which tend to appear later in the spring (Sommer et al. 2004). Therefore, floodplains could be managed to help control non-native fish species that are not adapted to winter and early spring inundation (Sommer et al. 2004, Moyle et al. 2007).

Due to the lack of river-floodplain connectivity throughout much of the Delta and its watershed, restoration of floodplains and other shallow-water habitats have been proposed to maintain biodiversity of native aquatic species and restore fisheries in the San Francisco Estuary by increasing phytoplankton abundance (Schemel et al. 2004). Declines in fishes and other aquatic species have been linked to reduced phytoplankton production and abundance. Sommer et al. (2001b) suggests that floodplain restoration could support the downstream food web as a result of enhanced production of phytoplankton and detritus material (Sommer et al. 2004). Phytoplankton-enrichment has been documented following high-flow years when the Sacramento River inundates its floodplains thereby stimulating the food web of fisheries and other biological resources (Schemel et al. 2004).

Historically, restoration efforts have been used to address fishery declines, including two major efforts in the estuary: the CVPIA and the CALFED Bay-Delta program. The listing of splittail in 1999 was the impetus for CALFED-funded floodplain restoration (Sommer et al. 2007a) in an effort to restore and enhance splittail spawning and rearing habitat lost due to Federal, State, and private water development projects (USFWS 2003). The total amount of habitat protected or restored was 45,700 hectares (ha), 6,500 ha of which was for floodplain. Since 1995, programs to support native fishes have invested $335 million in habitat restoration and water allocations in the Delta (Sommer et al. 2007a, Sommer et al. 2007b). The splittail was the first

extant fish ever to be removed from the list of threatened species following a court-ordered review of its original listing in 2003, when the USFWS determined that past habitat losses were offset by CALFED and the CVPIA efforts that enabled greater spawning and rearing opportunities, increased the population size, and reduced threats to a level below the point at which the splittail would meet the definition of a threatened species (USFWS 2003).

New research on native fishes has identified that restoration should consider different needs of different species. The initial proposal to list splittail assumed that the species was declining for reasons similar to other native fishes, including delta smelt and longfin smelt. Assemblages of species respond differently to environmental change and different cues, and therefore could pose a conflict in managing the Delta for different species (Sommer et al. 2007b, Moyle and Bennett 2008). Whereas splittail are perhaps the most floodplain dependent species in the estuary, Sommer et al. (2007b) states that longfin smelt and delta smelt that are found in the upper estuary do not make extensive use of floodplain habitat and therefore would probably derive little direct benefit from floodplain inundation.

Although there are many benefits to floodplain inundation, there are also concerns that must be addressed. Fish passage is a concern for sturgeon (Sommer et al. 2003) and areas with engineered water control structures may result in stranding (Sommer et al. 2005). Contamination of water and sediment, including organic carbon and natural organic matter, mercury (and methylmercury), pesticides, toxicity, and pathogens including bacteria is another major area of concern that would need to be considered before increasing floodplain inundation. Floodplain waters returning to the Delta contribute natural organic matter to the water, which when treated for potable use may react to form cancer-causing disinfection byproducts (Bergamaschi et al. 2000, Brown 2003).

Mercury contamination in fish is associated with floodplain areas and wetlands in the Bay-Delta system. Mercury contamination results from the conversion of inorganic mercury (Hg) to toxic methylmercury (MeHg) especially in the sediment of wetlands. Delta wetland environments and marsh regions, rather than open water areas, provide ideal conditions for the production of methylmercury, and wetland sites with the highest MeHg sediment concentrations also have highest MeHg concentrations in water (Stephenson et al. 2008). When the Yolo Bypass is flooded, it becomes the dominant source of methylmercury to the Delta (Foe et al. 2008). Flooding produces elevated methylmercury concentrations in the Yolo Bypass and San Joaquin and Cosumnes Rivers (Foe et al. 2008), which result in increased fish tissue concentrations (Slotton et al. 2008). Findings from fish mercury studies have found that episodic flooding of normally dry soils may increase production of methylmercury (Davis et al. 2007). Episodic flooding of usually dry soils is a primary factor leading to elevated methylmercury concentrations in the food web (Slotton et al. 2008).

Research suggests that restoration activities could exacerbate the existing mercury problem (Davis et al. 2007). As large new areas of wetland restoration are implemented in the Bay-Delta, there are concerns that newly flooded habitats will enhance mercury methylation and food chain exposure (Slotton et al. 2008). In addition, increased methylation may occur if restoration projects re-expose, accrete, or use dredged Hg-laden sediments (Takekawa et al. 2006), especially in anoxic conditions that transform inorganic Hg to MeHg. Foe et al. 2008 recommends that studies should be conducted to identify areas with large mercury deposits that may complicate downstream wetland restoration and increase methylmercury production. Careful selection of restoration projects may help minimize the extent of increased concentrations of methylmercury and mercury bioaccumulation.

The collapse in fish species in the Delta, including pelagic organisms, salmonids, and other native and game fish species, has provided the impetus for planned efforts to restore the Bay-Delta ecosystem to include consideration of inundation of seasonal floodplains to improve habitat quality and quantity in the watershed. Recognizing the importance of floodplains and riparian vegetation for numerous aquatic and terrestrial species, BDCP, the Delta Vision Strategic Plan, The Nature Conservancy (TNC), and CALFEDs ERP all include conservation strategies to restore important functions and values provided by floodplains in the Delta.

During the water quality control planning process, staff will need to consider efforts that support inundation of floodplain habitat in an attempt to find solutions for the fishery decline and to provide reasonable protection of beneficial uses. The BDCP planning process includes a core element listed in the current Draft Conservation Strategy to increase frequency and duration of floodplain inundation. Implementation of this core element is intended to increase habitat quality, quantity, connectivity, accessibility, and food supply, thereby enhancing covered species' productivity, abundance, distribution, diversity, growth and survival. Additionally, a recent PPIC report recommends that the State Water Board consider an experimental floodplain restoration program to evaluate the effects of inundation on desirable species (Lund et al. 2008). Other processes, such as the ongoing development of a statewide Wetland and Riparian Area Protection Policy and the California Water Quality Monitoring Council formed as a result of SB1070, should also be considered.

Conclusion: Staff recommends that the State Water Board investigate establishing water quality standards for flow or other flow-related requirements to support inundated floodplain habitat in the Bay-Delta watershed. At a minimum, this evaluation would include consideration of flow standards for the Yolo Bypass. Establishing any standards would require evaluation of potential impacts to beneficial uses, water quality effects, and other concerns such as water availability and fish passage. Development of floodplain standards should be closely coordinated with the Regional Water Boards, fisheries agencies, flood control authorities and other appropriate stakeholders. Staff also recommends that the State Water Board work closely with the BDCP parties during development of any floodplain standards or related requirements.

Changes to the Program of Implementation

Environmental Monitoring Program

Issue: Changes to Monitoring and Special Studies Program in the Bay-Delta Plan.

Staff Recommendation: Staff recommends that the State Water Board consider changes to the Monitoring and Special Studies Program based on available information as part of the review and potential revision of the Bay-Delta Plan.

Discussion: In the Bay-Delta Plan, the State Water Board requires a Monitoring and Special Study Program (Monitoring Program) to provide baseline physical, chemical, and biological information, and to determine compliance with the water quality objectives. It also requires studies that evaluate the response of aquatic habitat and organisms to the objectives, and increase understanding of large-scale characteristics and functions of the Bay-Delta ecosystem to better predict system-wide responses to management options. The water quality compliance and baseline monitoring portion of the Monitoring Program is referred to as the Environmental Monitoring Program (EMP). Pursuant to D-1641, DWR and USBR are required to perform baseline and compliance monitoring (Table 7 of Bay-Delta Plan) and to conduct the special studies. This work is coordinated through the IEP.

Since 1974, as required by the State Water Board, DWR and USBR monitor water quality conditions as well as phytoplankton, zooplankton, and benthos abundance and distribution in the Bay-Delta. The EMP is a valuable long-term environmental monitoring program, providing data and information for resource management and scientific understanding of estuarine processes. With more than three decades of uninterrupted data collection, the EMP has provided a consistent and comprehensive long-term environmental data record.

D-1641 requires review of the EMP every three years. The last full review of the EMP was conducted in 2003 (IEP 2003). Since the 2003 review, the benthic element portion of the EMP has been reviewed and a draft report is expected in spring 2009. Plans for a full review are being discussed within IEP. Additional reviews of other IEP elements include the upcoming planned review of the hydrologic and salmon elements.

The 2003 review included the following recommendations:

- Improve the ability to characterize spatial and temporal variability of ambient concentrations and fluxes of physicochemical and biological constituents
- Examine important constituents' concentrations and fluxes in key habitats
- Collect appropriate data for modeling
- Provide timely EMP data to decision makers

Monitoring activities in the Delta have changed since the last update to the Bay-Delta Plan, including many relevant monitoring activities that occur outside the legal boundary of the Delta. New monitoring activities are planned as part of ongoing processes that affect the Bay-Delta. Pursuant to the 2008 Bay-Delta Strategic Workplan, new monitoring activities include a proposed Regional Monitoring Program (RMP) for the Delta. Additionally, new or changed monitoring and assessment needs may also be identified in the BDCP process.

Ongoing monitoring efforts in the Bay-Delta and watershed include IEP POD-related studies, US EPA's San Joaquin River Monitoring and Assessment Strategy, the Water Board's Surface Water Ambient Monitoring Program (SWAMP), TMDLs, efforts related to fisheries and monitoring required under the ESA and the CESA, the United States Geological Survey's (USGS) National Water-Quality Assessment Program (NAWQA), the San Francisco Bay Regional Monitoring Program (RMP), and monitoring associated with proposed Sediment Quality Objectives of Enclosed Bays and Estuaries. Other examples include the San Francisco Bay Study, the VAMP, and DWR's Municipal Water Quality Investigations program (MWQI). The San Francisco Bay Study monitors the abundance and distribution of fish and mobile crustaceans in the Bay-Delta, primarily downstream of the Delta. The VAMP is a 12-year experimental management program to obtain scientific information concerning the effects of flows, exports, and barrier operations on Chinook salmon migrating from the San Joaquin River through the Bay-Delta. The MWQI mission is to monitor, protect, and improve the drinking water quality of water delivered to the urban State Water Contractors and other users of Delta water. This program focuses on monitoring and issues related to drinking water and includes monitoring both in the Bay-Delta watershed and downstream in the distribution system.

Although the Bay-Delta Plan does not specifically require monitoring of the hydrology of the Bay-Delta and its watershed, necessary flow and other flow data is collected, managed, reported and analyzed so that compliance with flow-related objectives may be determined. Flow information is extremely important because it provides the hydrologic record for the Bay-Delta upon which decisions can be made regarding the use and proper management of

water resources. Many of the flow stations in the Bay-Delta and its watershed are owned, maintained and operated by the USGS. DWR and USBR, among others, also maintain flow stations that provide hydrologic and related information (California Data Exchange Center 2009). The USGS San Francisco Bay Hydrodynamics Study conducts hydrodynamic transport investigations, in collaboration with a broad coalition of state and federal agencies (DWR, State Water Board, DFG, USBR, and USFWS), by using a combination of three components: Delta Flows Monitoring, Process-Based Field studies and Three-dimensional Modeling (USGS 2009). The Delta Flows Network provides long-term flow data at 21 stations throughout the Delta and uses newer technologies for measuring and modeling flow including the Acoustic Doppler Current Profiler (ADCP). Data from hydrologic monitoring stations are used on a daily basis by the water project operators. Data are also analyzed to understand how the tidal currents, river inflows, water project exports, temporary barriers, and DCC gate operations impact transport within the upper estuary. These data are also used routinely for numerical model calibration and validation and are regularly leveraged into large interdisciplinary process-based studies.

The numerous monitoring activities occurring in the Bay-Delta for a wide variety of purposes are a challenge to coordinate, especially with respect to data management, storage and assessment. Access to compatible data collected for multiple uses is important when several regulatory processes (e.g. control of point and non-point sources, control of flow related stressors, and addressing endangered species concerns) rely on the information collected. The California Water Quality Monitoring Council (2008) has recently made recommendations to help address these data management issues on a statewide level, including: (1) improve data accessibility; (2) standardize methods for monitoring, assessment, and data management to increase comparability; and (3) form theme-based workgroups that center monitoring and assessment programs around consistent performance measures.

The Delta Vision Committee Implementation Report (2008) recommends beginning comprehensive monitoring of Delta water quality and fish and wildlife health by 2010. The committee also recommends that legislation be enacted to streamline and simplify water diversion and use reporting requirements and that a pilot project be mandated to install real-time telemetered monitoring devices on surface water diversions in and tributary to the Delta. To the extent that comprehensive monitoring for the Bay-Delta and water use information help to inform decisions regarding the protection of beneficial uses of the Bay-Delta, the State Water Board should consider including these actions in the Bay-Delta Plan. In addition, the BDCP process has recognized the need for a monitoring and assessment element in any BDCP plan (2008). These recent planning activities for the Bay-Delta, together with newly prescribed monitoring and assessment needs related to ESA and CESA compliance, support further review and potential changes to the Monitoring and Special Studies Program.

Conclusion: Staff recommends that the State Water Board consider changes to the Monitoring and Special Studies Program as part of its review of the Bay-Delta Plan. Specifically, for reasons discussed above, the State Water Board should consider recommendations developed during reviews of the IEP/EMP, and other recommendations for modification that are available during the basin planning process. Requirements for flow measurements and hydrologic modeling should also be considered. The State Water Board should also consider new monitoring and assessment needs for the Bay-Delta, integration with other processes such as BDCP, and enhanced coordination with monitoring and assessment components of other water quality control programs to improve data compatibility.

Other Changes to the Program of Implementation

Issue: Changes to the program of implementation for the Bay-Delta Plan (other than the Monitoring and Special Studies Program)

Staff Recommendation: Staff recommends that the State Water Board consider changes to the program of implementation for the Bay-Delta Plan based on available information as part of its review and potential revision of the Plan.

Discussion: The Bay-Delta Plan includes: (1) beneficial uses to be protected, (2) water quality objectives for the reasonable protection of beneficial uses, and (3) a program of implementation for achieving the water quality objectives. The Bay-Delta Plan's program of implementation identifies five general categories for implementation actions: (1) measures within State Water Board authority, (2) measures requiring a combination of State Water Board authorities and actions by other agencies, (3) recommendations to other agencies, (4) a monitoring and special studies program (discussed in a separate section), and (5) other studies conducted by other entities that may be relevant to future proceedings.

Any change to the water quality objectives may require a corresponding change in the program of implementation. Moreover, in light of changed conditions in the Delta ecosystem and the regulatory environment since adoption of the Bay-Delta Plan, such as constraints imposed to protect endangered species, the State Water Board should consider whether the program of implementation should be updated, regardless of whether a particular objective is changed.

Pursuant to the State Water Board's water right authority, the board has assigned responsibility primarily to DWR, the USBR, or both, for implementation of the flow-based water quality objectives and the salinity objectives in the Bay-Delta Plan. Other water rights holders are assigned responsibility for portions of the flow-related objectives. The State Water Board may reallocate responsibility for meeting these objectives among water right holders or other entities based on information it receives in a water right proceeding or water quality proceeding.

Conclusion: If the State Water Board considers amending, deleting, or adding a particular objective as part of its review of the Bay-Delta Plan, then it should also consider modifying the program of implementation for that objective. Additionally, it should consider whether the program of implementation should be updated for objectives that are unchanged**.**

ISSUES NOT RECOMMENDED FOR FURTHER REVIEW

Ammonia Objectives

Issue: Ammonia concentrations in Delta and Suisun Bay waters

Staff Recommendation: The State Water Board should not consider establishing objectives for ammonia as part of its review and potential revision of the Bay-Delta Plan. The State Water Board should, however, continue coordination with the San Francisco Bay and Central Valley Regional Water Boards on ammonia and related Bay-Delta issues and continue its programs to develop regulations addressing toxicity and nutrients.

Discussion: In water, ammonia primarily exists in two forms, un-ionized ammonia (NH_3) and ammonium ion (NH_4^+), which are in equilibrium according to $NH_4^+ \leftrightarrow NH_3 + H^+$. The equilibrium between ammonium and un-ionized ammonia depends primarily on pH, and also on temperature and salinity. Collectively, ammonium and un-ionized ammonia are often referred to

as total ammonia or sometimes simply ammonia (although this can lead to confusion). Un-ionized ammonia is a gas that is toxic to animals and occurs in the water and in the air. Ammonium ion is an important nutrient for plants and algae that is dissolved in water.

Ammonia discharged into the waters of the Bay-Delta and tributary watersheds is currently regulated through the State's water quality control programs based on US EPA (1999) criteria. Recent studies suggest that water quality objectives and effluent limits based on these criteria may allow concentrations of ammonia in surface water that could result in adverse effects on the Bay-Delta ecosystem. For example, two recently published studies found that elevated ammonium levels (>4 µmol/L or ~0.056 mg/L) in Suisun Bay, can suppress the growth of phytoplankton in this area even when there is sufficient light (Wilkerson et al. 2006, Dugdale et al. 2007). In response to these recent studies, the State and Regional Water Boards are investigating whether more stringent ammonia criteria may be necessary to protect aquatic life in the Delta. Of specific concern are potential toxicity to delta smelt and impacts on algae that are the base of the Delta food web.

Ammonia Sources, Concentrations, Fate and Transport

Both ammonium and un-ionized ammonia are present in effluent from wastewater treatment plants that employ secondary treatment methods, but also in some types of agricultural run-off from the use of nitrogenous fertilizers, and as a result of atmospheric depositions. Many hydrodynamic, chemical and biological processes, affect the transport, fate, and effects of un-ionized ammonia and ammonium after discharge into waterways.

The Sacramento Regional Wastewater Treatment Plant (SRWTP) is the largest point source of ammonium and ammonia in the Delta. The SRWTP's output has increased with human population growth and it has contributed to an increase in ammonium concentrations in the Delta downstream of the discharge. The discharge from the SRWTP accounts for 90 percent of the ammonium load in the Sacramento River at Hood (Jassby 2008). The Central Valley Water Board's current total ammonia requirements for the SRWTP are based on the US EPA (1999) aquatic toxicity guidance that is designed to protect the most sensitive aquatic species. The receiving environment downstream of SRWTP's effluent discharge is in compliance with the US EPA ammonia criteria. When writing a permit, Regional Water Board staff evaluates effluent concentrations, concentrations of total ammonia already in the river, and available dilution. Limitations in permits are, therefore, site specific. The SRWTP's permit allows for discharge of relatively high concentrations of total ammonia because the Sacramento River provides considerable dilution. SRWTP uses large storage basins to hold wastewater for short periods of time when there is not sufficient dilution in the river because of reverse tidal flows. The City of Stockton, on the other hand, has lower effluent ammonia limits because little dilution is available in the San Joaquin River. The Central Valley Water Board required Stockton in its 2002 permit (R5-2002-0083) to upgrade its wastewater treatment facility to add treatment processes to remove ammonia. These facilities are now operational, resulting in a significant reduction in the amount of ammonia discharged. Additional sources of ammonium to the Delta and Suisun Bay include other wastewater treatment plants, agricultural run-off, atmospheric deposition, internal cycling, and possibly discharges from wetlands.

There are several municipal and industrial wastewater discharges in the vicinity of Suisun Bay that are regulated by the San Francisco Bay Water Board. As permits for these facilities come up for renewal, Water Boards staff will evaluate the need for ammonia limits using currently applicable objectives in accordance with the basin plan. If ammonia limits are indicated, they will be proposed for inclusion in the NPDES permit. Ammonia monitoring is routinely done by dischargers and under the San Francisco Bay Regional Monitoring Program (RMP). The RMP

is also investigating the scientific information on the potential impacts of ammonia in Suisun Bay and San Francisco Bay.

The IEP EMP has been monitoring ammonium concentrations at monthly or biweekly intervals at 10 stations in the Delta and Suisun Bay since 1975. The EMP did not collect simultaneous pH measurements after 1995, so it is not possible to calculate un-ionized ammonia and compare ambient levels to US EPA (1999) acute and chronic criteria at these stations after 1995. In addition to the IEP, several other programs and investigators are collecting ammonium and associated water quality data from around the Delta (e.g., DWR-Municipal Water Quality Investigation stations, USGS monitoring stations, NPDES permit receiving water monitoring stations, and ongoing UC Davis research). Various entities are currently compiling a summary of sources and concentrations of ammonium in the Delta based on readily available data collected by existing monitoring programs. The goals of these compilations are to better characterize sources, trends, and data gaps, and to support development of an ammonium fate and transport model. Additional work may be needed to improve hydrodynamic modeling and conduct more in-depth investigations of chemical, biological, and hydrodynamic conversion and mixing rates downstream of discharge points and throughout the Delta and Suisun Bay.

The Central Valley Water Board is currently conducting an ammonia sampling program in the Delta. The purpose of this study is to collect additional nutrient data, including ammonium and un-ionized ammonia, for the Delta to determine whether ambient concentrations are potentially toxic, and to support development of a fate and transport model. A spatial emphasis is placed on the lower Sacramento River and northern Delta as ammonia levels from the SRWTP are likely to be highest here. However, other areas of the San Francisco Bay Estuary are also proposed for sampling as SRWTP is not the only source of ammonia/ammonium.

Ammonium Effects on Delta Phytoplankton

Primary production rates and standing chlorophyll *a* levels associated with phytoplankton (open water algae) in the Delta and Suisun Bay are among the lowest of all the major estuaries in the world (Boynton et al. 1982, Jassby et al. 2002, Cloern and Jassby 2008, Jassby 2008). Chlorophyll *a* and primary productivity levels in the Delta declined from 1975 to 1995, but have increased significantly from 1996-2005, while Suisun Bay levels remained relatively unchanged over the last decade (Jassby et al. 2002, Jassby 2008).

The composition of the phytoplankton community has generally shifted from diatoms toward green algae, cyanobacteria, and miscellaneous flagellate species (Lehman 2000). Blooms of *Microcystis aeruginosa*, a cyanobacterial harmful algal bloom species that can produce toxic substances, have been observed in Delta waters since 1999 (Lehman et al. 2005). The changes in phytoplankton composition and especially the now regularly occurring *Microcystis* blooms have been implicated as possible factors in the decline of important Delta pelagic fish species including delta smelt (Baxter et al. 2008a), but the connection with ammonia is not clear.

Low light availability and high grazing rates have been identified as important factors controlling overall phytoplankton production and biomass in the Delta. Much of the interannual variation in phytoplankton biomass can be attributed to the effects of precipitation and associated river flows on nutrient and suspended solids loads (Cloern 2001, Jassby et al. 2002, Lehman 2004). Nutrients are generally thought to be of lesser importance in this turbid, nutrient-rich estuary, although one study (Van Nieuwenhuyse 2007) found an association between an abrupt decline in total phosphorus concentrations due to reductions in urban phosphorus discharges in the

mid-1990s and a decline in chlorophyll *a* levels at three Delta EMP stations (D26, D28A, and MD10).

Ammonium is known as an important, but also "paradoxical" nutrient (Britto and Kronzucker 2002) because it can stimulate plant growth, but also suppress plant uptake of another important nutrient, nitrate, and ultimately suppress growth of some sensitive plants. This type of sensitivity to ammonium is well established for many agricultural crops. Two recently published studies show that high ammonium levels (>4 µmol L^{-1} or ~0.056 mg L^{-1}) in Suisun Bay, once considered one of the most productive areas of the San Francisco Bay Estuary, can suppress the growth of phytoplankton in this area even when there is sufficient light (Wilkerson et al. 2006, Dugdale et al. 2007). Diatoms appear to be particularly affected by relatively low levels of ammonium in Suisun Bay. It is not known whether the same effect is manifested in the freshwater portions of the Delta.

Pilot level investigations conducted by the Dugdale and Wilkerson Laboratory in 2007 and 2008 have repeatedly shown suppression of phytoplankton growth in the lower Sacramento River near Rio Vista and a site on the lower San Joaquin River downstream of Stockton. Two tests conducted in 2008 with Sacramento River water collected near the discharge point of the SRWTP, however, showed good phytoplankton growth in spite of high ammonium concentrations. The reasons for different growth responses in the Sacramento River near the SRWTP discharge compared to samples near Rio Vista and from the San Joaquin River stations are unclear and investigations will continue with increased intensity in 2009. Once the results of these studies are complete, further work may be needed to determine the relative importance of the effect of ammonia mass loading and concentrations on the Delta food web.

Ammonium Effects on Harmful Algal Blooms and Invasive Aquatic Plants

Elevated ammonium concentrations potentially contribute to harmful algal blooms (e.g., *Microcystis*) that have been occurring with increasing frequency and biomass in some parts of the Delta (Lehman et al. 2005). A recent study in the San Francisco Bay Estuary found that low stream flow and high water temperature were strongly correlated with the seasonal variation of *Microcystis* cell density, total microcystins concentration ($cell^{-1}$) and total microcystins concentration (chl a^{-1}), while ambient nutrient concentrations and ratios were of secondary importance (Lehman et al. 2008).

As has been shown elsewhere, elevated levels of ammonium and other nutrients may also benefit invasive rooted and floating aquatic plants in the Delta, such as the water hyacinth (*Eichhornia crassipes*) and the Brazilian waterweed (*Egeria densa*) (Reddy and Tucker 1983, Feijoó et al. 2002). Both species are now widely distributed across the Delta (Hestir et al. 2008) and are controlled in Delta channels through chemical herbicides and mechanical removal by the California Department of Boating and Waterways.

Ammonia Effects on Delta Smelt

In the spring of most water years, larval delta smelt are captured in trawl net surveys about 30 miles downstream of the City of Sacramento, near the confluence of the Sacramento River and Cache Slough. Recent studies of toxicity in the Sacramento River and Delta led to the hypothesis that larval delta smelt may be particularly sensitive to ammonia (Baxter et al. 2008b).

In 2008, UC Davis Aquatic Toxicology Laboratory (UCD ATL) conducted a pilot study to assess the potential acute toxicity of ammonia and treated wastewater effluent from the SRWTP to larval delta smelt. The bioassay results suggest that ammonia concentrations present in the Sacramento River below the SRWTP were not acutely toxic to 55-day old delta smelt (Werner et

al. 2009). The results from this study were consistent with total ammonia and un-ionized ammonia effect concentrations established for 50-day old delta smelt using filtered hatchery water (UCD ATL unpublished data, Werner et al. 2009). At 50 days old, delta smelt are about as sensitive to total ammonia and un-ionized ammonia as salmonid species, and about five times more sensitive than larval fathead minnow (UCD ATL unpublished data, Werner et al. 2009), a common toxicity test species used by the SRWTP and other dischargers in accordance with their discharge permits.

Ammonia may contribute to the POD if its concentrations in Delta waters are high enough to cause direct toxicity to the POD fishes or their food organisms. It is well known that salmonids are particularly sensitive to ammonia (US EPA 1999). In general, un-ionized ammonia levels in the Delta appear to be too low to cause acute mortality of even the most sensitive species.

Questions remain about the potential for chronic (i.e., long-term, sub-lethal) impacts from ammonia as well as the impacts in sensitive delta smelt spawning areas (e.g., Cache Slough). Un-ionized ammonia concentrations in the Delta do exceed levels where histopathological effects have been observed (US EPA 1999); however, it is unclear whether these effects translate to effects on survival, growth or reproduction. In addition, there is some evidence that actively swimming and unfed fish may be several times more sensitive to ambient un-ionized ammonia levels than these laboratory exposures indicate (Eddy 2005).

There may be a potential for toxic ammonia levels to be reached in very productive areas in the southern Delta or smaller productive sloughs or shallow areas throughout the Delta, when high concentrations of un-ionized ammonia coincide with warm temperatures and elevated pH (phytoplankton productivity increases pH that influences how much un-ionized ammonia is present). The relatively few ammonium, temperature, and pH data available in many of these areas are currently being compiled and evaluated.

In addition, the potential for combined effects of un-ionized ammonia with other toxicants and stressors, and differences in fish sensitivity depending on health status, age, and physiological state, add uncertainty to data analyses. While un-ionized ammonia interactions with other toxicants and variable sensitivity have been demonstrated for a variety of species (e.g., Eddy 2005, Camargo and Alonso 2006), similar studies for the POD fishes are in their initial stage. Much more work is needed to reduce the many uncertainties about chronic toxicity effects of ammonia on the POD fishes in various Delta regions and discern population level effects.

Ammonia Workshop

The CALFED Science Program hosted a workshop on March 10th and 11th 2009 to provide a venue for open discussion among interested persons to identify data and science gaps and develop a research framework to determine the role of ammonium/ammonia within the Bay-Delta ecosystem. A panel of national experts in riverine and estuarine nutrient dynamics, food web processes, and ecotoxicology was convened and tasked with assessing the best available science in a workshop setting and preparing the research framework with input from local experts, stakeholders, and the interested public.

According to the research framework, the most important gap to be filled in the Bay-Delta research program is the development of an over-arching, integrative model of the major drivers controlling the Bay-Delta ecosystem (Meyer et al. 2009). Of prime importance to this effort is an integration of the understanding of the roles of hydrology, nutrients, and herbivory in the temporal dynamics of phytoplankton production and community composition (Meyer et al. 2009). The expert panel identified the following as crucial knowledge that needs to be

generated and/or expanded to support the model: (1) an analysis of sources (exogenous and endogenous, or from outside of and within the system), sinks, and transformations of nitrogen along the Delta-to-Bay continuum, and controls on those pools and processes; (2) an understanding of factors that control POD populations, including various forms of nitrogen and a combination of other stressors, including chemicals, food availability and hydrology (including water-withdrawal systems); and (3) field observations of POD species and other potentially interacting and/or sensitive taxonomic groups (Meyer et al. 2009). In addition, a suite of more specific recommendations concerning the types of research projects that could address these research gaps are provided.

The research framework, combined with input obtained during workshop discussions and the upcoming Ammonia Summit (see below), will be used to develop a Data and Science Gap Analysis (Analysis). The Analysis will be prepared by the workshop planning committee, which is comprised of agency staff and interested stakeholders. It is intended to identify the specific research needs that are not already being addressed and answer questions and uncertainties concerning the role of ammonia/ammonium within the Bay-Delta ecosystem. After addressing comments provided by the expert panel, the Analysis will be provided to the POD-Contaminants Work Team (CWT) for distribution to POD investigators and funding agencies. The intent is that this document will be updated by the POD-CWT as studies are completed, new understanding is generated, and new research questions are developed.

Ammonia Summit

The Central Valley Water Board is planning to hold a conference in the summer of 2009, as a follow-up to the CALFED ammonia workshop. This summit is intended to provide a broader and more in-depth forum for presenting findings of current research and gathering scientific information relevant to the study of the role of ammonia/ammonium in the Bay-Delta ecosystem. The conference will include scientific presentations and facilitated discussions grouped into three main topic areas: sources, concentrations, fate and transport of nutrients; food web effects; and toxicology. The conference is currently in the initial planning phase, and additional details will be released as they become available.

Related Regulatory Programs

The State Water Board is in the process of state policy to address toxicity and the impacts of nutrients on surface waters statewide. Either or both of these regulatory approaches could be applied to limit ammonia concentrations in Delta waters; one through limits on ammonia as a plant nutrient, the other through limits on the toxic effects of ammonia in surface waters. The State Water Board has developed a methodology, the Nutrient Numeric Endpoints framework, for translating narrative limits on biostimulatory substances into numeric objectives for streams, rivers, and lakes. The NNE framework takes into account the impacts on beneficial uses by measuring the effects of nutrients rather than just the concentrations (i.e. effects on dissolved oxygen, pH, algal biomass etc.). The NNE framework also accounts for secondary or indirect, factors such as residence time, scouring flows, shading, and temperature which can change the assimilative capacity for nutrients. This framework is currently being adapted for application to estuarine waters. The State Water Board is also developing numeric objectives for toxicity as part of its Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California. If adopted, these objectives would place limits on toxicity levels in receiving waters based on standardized toxicity tests.

Conclusion: In general, current Delta ammonia concentrations appear to be far lower than concentrations that US EPA (1999) guidance indicates may cause acute mortality of even the most sensitive fish species. If current and follow-up studies indicate that US EPA's (1999) water

quality criteria do not ensure reasonable protection of beneficial uses in the Bay-Delta, the Central Valley and San Francisco Bay Water Boards will evaluate the need for stricter requirements on all sources of ammonia and ammonia precursors. Primary responsibility for developing and implementing control programs addressing ammonia, including possible basin plan amendments, should remain with the Regional Water Boards so they can be integrated into their other water quality control programs. The State Water Board will continue to monitor efforts related to this issue and may decide to take additional actions through any of its water quality programs if warranted.

Toxicity objectives

Issue: Toxicity to fish and other aquatic organisms in the Delta.

Staff Recommendation: The State Water Board should not consider objectives for toxicity as part of its update of the Bay-Delta Plan. The State Water Board should, however, continue coordination with the San Francisco Bay and Central Valley Regional Water Boards on toxicity and related Bay-Delta issues and continue its efforts to develop statewide regulations addressing toxicity.

Discussion: Toxicity to aquatic life can be defined and measured in various ways. Direct toxicity to test organisms under controlled laboratory conditions estimates the total toxicity present in a sample by measuring an organism's response compared to clean control water. Endpoints measured with toxicity tests include mortality, growth, and reproduction, and a variety of species may be used depending on the objectives of the testing. Histopathological (tissue) analyses of organisms from water bodies of interest can also provide evidence of exposure to toxic chemicals. Histopathologists evaluate tissue samples for evidence of contaminant exposure including lesions or evidence of disease or infection. Another method of estimating exposure to contaminants is use of biomarkers, which is a measure of sub-lethal chemical endpoints such as enzyme activity or endocrine disruption that cannot be measured with standard toxicity tests.

Toxicity in the Delta

Toxicity (estimated with standard laboratory toxicity tests) in water and sediments in the Delta and upstream watersheds has been reported since the late 1980s (Kuivila and Foe 1995; Giddings et al. 2000; Werner et al. 2000; Weston et al. 2004). Young striped bass mortality caused by discharge of agricultural drainage water containing rice herbicides into the Sacramento River (Bailey et al. 1994) led to new regulations on those discharges. Bioassays using caged fish revealed DNA strand breakage associated with runoff events in the watershed and Delta (Whitehead et al. 2004). Kuivila and Moon (2004) found that peak densities of larval and juvenile delta smelt sometimes coincided in time and space with elevated concentrations of dissolved pesticides that could have detrimental effects in the spring. While the concentrations of individual pesticides were low, and much lower than would be expected to cause acute mortality, the effects of exposure to the complex mixtures of pesticides are unknown.

Historically, contaminants have not been a focus of the IEP. Discovery of the severe decline in abundance of four pelagic fish species and some zooplankton in the Delta stimulated interest in investigating contaminants as a potential causal factor. Since 2005, UC Davis has conducted toxicity testing of waters collected from the Bay-Delta as part of the IEP's studies of the role of contaminants in the POD. Studies in 2005 and 2006 focused on the summer months when juvenile delta smelt are present in the Delta. To better characterize toxicity during the smelt

spawning period, bi-weekly toxicity screening was initiated in January 2007 and continued through 2008.

In 2005 and 2006, low (<5 percent) frequency of occurrence of toxicity was observed in laboratory toxicity tests using the amphipod *Hyalella azteca* (Armor et al. 2006). The frequency of toxic events was higher in 2007, and observed in locations where delta smelt larvae were present and where delta smelt were presumed to be spawning (i.e., lower Sacramento River and the Cache Slough complex). The screening tests suggested organophosphate (OP) pesticides or pyrethroid pesticides were potential causes of the toxicity to *H. azteca*; however, follow-up studies were inconclusive and chemical analyses either detected no pesticides, or the concentrations detected were not high enough to cause toxicity to the test species.

Larval delta smelt toxicity tests were conducted simultaneously with a subset of the *H. azteca* toxicity tests. Results from 2006 indicate that delta smelt may be more sensitive to toxicants, or perform poorly (e.g. higher mortality due to physical stress) in laboratory toxicity tests, when waters tested were of low turbidity and salinity. There is preliminary indication that disease organisms may play a role in reducing survival under low salinity conditions (Werner et al. 2008a). No significant mortality of larval delta smelt was found in the 2006 bioassays, but there were two instances of significant mortality in June and July of 2007 (Werner et al. 2008a). In both cases, the water samples were collected from sites along the Sacramento River and had relatively low turbidity and salinity. Neither of these instances coincided with toxicity to *H. azteca*. The delta smelt toxicity test procedures are under development and continue to be refined. As yet, no toxicity identification evaluation methods are available to determine the cause of the observed toxicity.

In 2008, few incidents of toxicity to *H. azteca* or delta smelt were observed (Werner et al. 2009, Werner et al. unpublished data). In April and May 2008 UC Davis conducted a pilot study with the copepod *Eurytemora affinis*, an important food species for delta smelt and other larval fish. Significant toxicity was observed in samples from the lower Sacramento River and Cache Slough area (Teh et al. 2009). The same samples were not toxic to *H. azteca*, indicating that *E. affinis* may be more sensitive than the standard test species.

The POD investigations into potential contaminant effects also include the use of biomarkers that have been used previously to evaluate toxic effects on POD fishes (Bennett et al. 1995, Bennett 2005). The results to date have been mixed. Foott et al. (2006) reported no histological abnormalities associated with toxic exposure or disease in both longfin smelt and threadfin shad. Adult delta smelt collected from the Delta during winter 2005 also were considered healthy, showing little histopathological evidence for starvation or disease (Teh et al. unpublished data). However, there was some evidence of low frequency endocrine disruption. In 2005, nine of 144 (six percent) of adult delta smelt males were intersex, having immature oocytes in their testes (Teh et al. unpublished data).

In contrast, preliminary histopathological analyses have found evidence of significant disease in POD and other fish species collected from the Delta. Intestinal infections were found in yellowfin goby (*Acanthogobius flavimanus*) collected from Suisun Marsh. Severe viral infections were found in inland silverside (*Menidia beryllina*) and juvenile delta smelt collected from Suisun Bay during summer 2005 (Baxa et al. in prep.). Ostrach et al. (in prep.) found high occurrence and severity of parasitic infections, inflammatory conditions, and muscle degeneration in young striped bass collected in 2005, and lower occurrence of these parameters in fish collected from 2006. Further, striped bass may be especially vulnerable to contaminant effects because the

long lived females can sequester contaminants bioaccumulated over several years in egg yolk that can result in contaminant effects in developing embryos and larvae (Ostrach et al. 2008).

As with ammonia, discussed in the previous section, the San Francisco Bay Water Board has been working with the Central Valley Water Board and others to determine the extent, magnitude, and ecological impacts of observed toxicity in the Bay-Delta system. Although most of the monitoring and investigation effort has taken place in the Delta, a few instances of toxicity have been observed in Suisun Bay.

Sources of Toxicity

As noted above, pesticides from agricultural and stormwater runoff are one source of toxicity in Delta waters. The Central Valley Water Board has been concerned about OP and other pesticides in Delta water since the late 1980s. In the early 1990s, toxic concentrations of OP pesticides were present in the rivers and Delta channels for several days at a time (Deanovic et al. 1996). In response, the Central Valley Water Board developed and adopted TMDLs to reduce concentrations of diazinon and chlorpyrifos in the Delta and tributaries. The OP TMDLs also include provisions designed to ensure that replacement pesticides, such as pyrethroids, do not become a problem. Urban uses of the OP pesticides have been phased out, the overall agricultural use of diazinon and chlorpyrifos has been significantly reduced, and new label restrictions have been adopted to reduce the amount of these pesticides that enter waterways from agricultural operations. Implementation of the TMDLs by the Central Valley Water Board, other State agencies, and stakeholders, has resulted in a decrease in concentrations of diazinon and chlorpyrifos in the Delta and upstream tributaries.

Pyrethroids are of particular interest because use of these pesticides has increased (Amweg et al. 2005, Oros and Werner 2005) as use of some OP pesticides has declined. Toxicity of sediment-bound pyrethroids to macroinvertebrates has also been observed in watersheds upstream of the Delta (Weston et al. 2004, 2005, 2009). There is limited information about concentrations of pyrethroids in the Sacramento River and Delta channels. Preliminary information from studies in urban areas suggests that toxicity associated with pyrethroids is mostly confined to the sediment and that the area of impact is not far downstream from the source (Weston et al. 2005). These studies have prompted the California Department of Pesticide Regulation to place pyrethroid pesticides under re-evaluation, and to work with registrants to gather more information on fate and transport to evaluate whether revisions to current label restrictions are warranted. These limited studies and datasets suggests that there is a need to conduct more monitoring for pyrethroids in the Delta to better characterize potential impacts.

Irrigated agriculture is one source of pesticides in our waterways. The Central Valley Water Board has been working with agricultural water quality coalitions, through the Irrigated Lands Regulatory Program, to identify constituents of concern through monitoring, identifying sources of pollutants, and developing and implementing corrective actions when needed. Much work remains to be done, but monitoring data have not shown toxic concentrations of pesticides in Delta waterways that would indicate that runoff from agricultural lands is a definitive cause of the POD.

National Pollutant Discharge Elimination System (NPDES) permits for most wastewater treatment plants in the Delta adopted over the last decade have become more stringent over time after recognizing the critical conditions of the Delta, including limited dilution, receiving water toxicity, low dissolved oxygen, and the presence of endangered species. Many treatment plants have either completed major upgrades to include tertiary filtration and

nitrification/denitrification to remove ammonia, or are nearing completion of the upgrades. Stockton, for instance, recently completed a major expansion of their facility that includes upgrading of its tertiary filtration system and installation of ammonia removal systems. The upgrades address toxicity and dissolved oxygen issues. One notable exception is the SRWTP, which has less stringent permit requirements due to the large dilution effects of the Sacramento River to which they discharge. As noted in the section on ammonia discharges, the Central Valley Water Board is working with the SRWTP to evaluate the potential impacts of their discharge on delta smelt and algal primary production in the Delta. The need for more stringent permit requirements will be evaluated once the studies are complete.

While increased regulatory requirements on waste discharges to the Delta and upstream tributaries have reduced the frequency and severity of documented toxicity in the Delta, toxic events, at a reduced frequency and intensity, continue to occur. Currently, UC Davis is compiling available data on toxicity and contaminants in the Delta, and the Central Valley Water Board is developing a framework for regularly compiling, assessing, and reporting on available data from existing monitoring programs. These products will be evaluated to identify sources of toxicity and contaminants to Delta waterways and determine whether there is need to establish more stringent regulatory requirements on discharges. Requirements could be implemented in the form of additional restrictions in permits (waste discharge requirements), conditional waivers of waste discharge requirements, or basin plan amendments to establish water quality objectives for toxic constituents. In addition, in San Francisco Bay, including Suisun Bay, the Regional Monitoring Program has been monitoring numerous (over 100) pollutants and toxicity since 1993.

Additional research is needed to determine the effects of emerging contaminants, such as endocrine disrupting compounds, on the Delta ecosystem. Further studies designed to validate the ecological relevance of biomarkers are also warranted. The identification of causal mechanisms and ecological relevance associated with the results of biomarker studies are necessary to evaluate the need for additional regulation. As these issues are not unique to the Delta, they are better addressed on a statewide basis.

Related Regulatory Programs

State Water Board staff is currently working on revising the toxicity control provisions contained in the Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California. Elements of the proposed revisions include establishing numeric toxicity objectives, establishing the appropriate statistical methods to use in determining whether a sample is toxic and establishing minimum test frequencies for inclusion in permits. Staff is also exploring possible revisions in determining when toxicity limits must be incorporated into permits (i.e. when a discharger has reasonable potential to cause or contribute to an exceedence of the objectives).

Conclusion: Since toxicity is likely linked to discharges from sources regulated by the Regional Water Boards, primary responsibility for implementing control programs addressing toxicity, including possible basin plan amendments, should remain with the Regional Water Boards. State Water Board development of statewide numeric objectives for toxicity would support Regional Water Board implementation by providing targets for program implementation and simplifying the process of developing toxicity limits in discharge permits. The State Water Board will continue to monitor efforts related to this issue and may decide to take additional actions through any of its water quality programs if warranted.

Fish Screen Objectives

Issue: Fish screening requirements for the protection of fish and wildlife beneficial uses in the Bay-Delta

Staff Recommendation: Staff does not recommend that the State Water Board consider establishing uniform requirements for fish screens as part of its review and potential revision of the Bay-Delta Plan. Instead, fish screens should be considered on a case-by-case basis through the water rights process.

Discussion: Staff review of fish screens and diversions for both SWP and CVP export facilities (project) and non-project diversions in the riverine and in-Delta portions of the Bay-Delta watershed relies principally upon the following scientific literature: Moyle and Israel 2005, Nobriga et al. 2004, Hanson 2001, and Kimmerer 2008. In addition, staff considered information from CALFED, Delta Vision, and other sources.

Non-project Diversions

As of 1997, there were over 3,500 diversions in the Bay-Delta watershed, of which approximately 98.5 percent were unscreened or screened insufficiently to prevent fish entrainment (Herren and Kawasaki 2001, pg. 343). The impacts of these diversions on fish populations is believed to be highly variable based on the location, size, timing of diversions, and other issues (Moyle and Israel 2005). In addition, the risk to specific species appears to be strongly affected by fish habitat use, size, and diet behavior (Nobriga et al. 2004). Very few quantitative analyses, however, have been conducted related to the effectiveness of fish screens in preventing fish losses or population level effects (Moyle and Israel 2005).

Moyle and Israel (2005) present the most comprehensive review of the literature to date on the effectiveness of screening non-project diversions for conservation of fish populations. The general findings from the review were that there have been few studies that have attempted to evaluate the effectiveness of fish screens and even fewer that have evaluated the effects of screening related to fish populations in the Central Valley and throughout the United States, even though millions of dollars are spent on installing and maintaining screens. At the same time, considering the large number of diversions and amount of water diverted, even small diversions can be a significant source of fish mortality given the large number of diversions and quantity of water diverted.

In their review of literature produced prior to 2000, Moyle and Israel found only one paper that evaluated the effects of unscreened riverine diversions in the Sacramento and San Joaquin Rivers (Hallock and Van Woert 1959). This paper attempted a broad, though not rigorous, evaluation of fish losses attributable to unscreened diversions. The findings from that report, related to the Sacramento River, indicate that: (1) larger diversions entrain more fish; (2) total numbers of salmon entrained by the diversions were surprisingly small, which was attributed to lack of overlap between the primary agricultural diversion season and the primary salmon out-migration periods; (3) numbers of fish entrained were highly variable between diversions and over time, but was often quite low; (4) many species were entrained and that entrainment was in order of abundance, and many entrained individuals were invasive species. With regard to diversion on the Sacramento River, the authors concluded that there were few locations upstream of the City of Meridian where appreciable losses of salmon or steelhead occur from irrigation diversions. They also concluded that individual diversions do not destroy many salmonids, but diversions collectively take considerable numbers of fish. In contrast, Hallock and Van Woert's analyses on the San Joaquin River showed that all of the large diversions

were destroying large numbers of salmon fry, likely related to the fact that 20 to 40 percent of San Joaquin river flow is diverted during salmon out-migration periods. Despite mixed results from this study, Hallock and Van Woert recommended that all diversions be screened due to cumulative effects (Moyle and Israel 2005).

A paper by Dr. Charles Hanson relating to the rate of juvenile Chinook salmon entrainment at unscreened diversions on the Sacramento River compared to the volume of water diverted, showed that the rate of juvenile salmon entrainment was not proportional to the volume of water diverted. Tests at two different pumping plants on the Sacramento River showed that on average the percentage of marked juvenile salmon entrained was one tenth of the corresponding percentage of Sacramento River water that was diverted. The results, however, were limited due to the low percentage of Sacramento River water diverted, the use of hatchery fish, the short distance between the release locations and diversions, and the size and configurations of the diversions (Hanson 2001).

Relating to in-Delta agricultural diversions, there are approximately 2,200 diversions all of which are shore-based and almost all are small (30 to 60 cm pipe diameter) and unscreened (Nobriga et. al 2004). Although the literature is limited, studies reviewed by Moyle and Israel indicate that loss of larvae and eggs in small diversions were proportional to their densities in the surrounding water bodies and the amount of water diverted, and that fish screens can greatly reduce the loss of fish in diversions. Studies also indicated that a large proportion of the fish captured in diversions in the Delta are non-native warm water fishes, and benthic fishes are more likely to be entrained than pelagic fishes. Regarding Suisun Marsh, the most intensive study relating to entrainment from small diversions indicates that most diversions in the marsh "are likely not diverting many fish and are having a negligible impact on fish populations" (Moyle and Israel 2005).

Nobriga et al. (2004) published results of the longest continuous monitoring of fish entrainment at Delta agricultural facilities to date. Results from that study indicate that vulnerability of fish to diversions varies by species, habitat use, size, and time of day and that additional information is needed to understand the effects of tidal dynamics, channel size, distribution of fish over time, and other issues. This study also found that a large number of larval and post-larval fishes were entrained in unscreened diversions and that installation of fish screens reduced entrainment by 99 percent or more. More than 99 percent of the species entrained in the unscreened diversions, however, were non-native. Nobriga et al. found that few delta smelt were captured at unscreened diversions even though they were captured at higher numbers in adjacent trawl surveys, likely due to the fact that delta smelt do not generally inhabit near shore habitat where diversions are located, and that small diversions have likewise small hydrodynamic influences. Nobriga et al. concludes: "[u]ltimately, a modeling approach will probably be needed to confirm that a large-scale screening program for delta irrigation diversion is an effective component of a comprehensive restoration strategy for delta smelt and other species."

SWP and CVP Export Facilities

Regarding the SWP and CVP export facilities, there are numerous and complicated factors related to their operations that lead to mortality for fish species of concern. The SWP and CVP export facilities can cause direct mortality to large numbers of fish and aquatic organisms due to entrainment and impingement. This direct mortality is related to the effectiveness of the existing louver devices to exclude fish from direct diversion (screening). In addition, the SWP and CVP export facilities also contribute to potentially significant causes of indirect mortality, resulting from the location, timing, and magnitude of the diversions and effectiveness of salvage operations (non-screening factors). These factors include: changes in flow paths through the

Delta that results in straying and stranding of fish into less desirable habitat areas; pre-screening mortality in Clifton Court Forebay from predation; salvage mortality from predation, handling, and potentially other factors; and removal of food sources from the Delta which adversely affects populations that rely upon these depleted food sources. Fish losses related to these indirect factors can be substantial, but the effects on the ecosystem are not known (CALFED 2008).

Recent attempts by Dr. Wim Kimmerer to quantify potential population losses of Sacramento River Chinook salmon and delta smelt at the SWP and CVP export facilities indicate that proportions of Chinook salmon salvaged at the export facilities increase with increasing exports and may be as high as 10 percent of the total migrating population. Losses of delta smelt to entrainment are associated with Old and Middle River flows and are estimated to vary widely, the range of loss of population in a single year was calculated to be from near zero to as high as 69 percent for adults and 62 percent for larvae. Pre-salvage survival of fish and survival of fish after being released from salvage is not known, but believed to be low due to high predation rates. In addition, indirect losses related to changes in hydrodynamics and other factors may be large but have not yet been estimated, nor has a method been developed to estimate them. Kimmerer concludes that systemic problems with the State and Federal Water Project fish facilities may make it impossible to understand all of their effects, and more importantly, to reduce them to an acceptable level (Kimmerer 2008).

In 2000, the CALFED ROD called for development and construction of fish screening devices at the SWP and CVP export facilities in the southern Delta. However, due to concerns related to cost (as high as $1.7 billion) and effectiveness of screening these facilities, screening activities were not pursued (CALFED 2005). Current discussions relating to development of a long-term solution to the impacts of the SWP and CVP export facilities on fisheries (Delta Vision and the BDCP) are centered around construction of an alternate point of diversion on the Sacramento River with sophisticated screening devices. In the interim, the Delta Vision Strategic Plan also calls for construction of a demonstration fish protection screen at Clifton Court Forebay, and conduct of a pilot study to determine the effectiveness of the screens in reducing fish kills and predation losses (Delta Vision 2008).

Conclusion: There is limited available information regarding the effectiveness of fish screens in protecting populations of aquatic species of concern. The literature indicates that the location, timing, magnitude, and other issues associated with the diversion largely dictates the effectiveness of installing fish screens in providing protection. Accordingly, the available information does not support establishing a uniform screening requirement through the basin planning process. Establishment and implementation of a uniform requirement to install fish screens on all diversions in the Bay-Delta watershed would require significant resources and time on the part of the State Water Board and the diverters and may not yield significant results in maintaining or improving populations of interest. Instead, screening requirements should be considered on a case-by-case basis, whether for an individual diversion or group of diversions with common attributes, through the water right process.

Accordingly, staff recommends that the State Water Board consider any screening requirements in coordination with DFG and as a part of its water rights processes. Specifically, as DFG identifies diversions of concern or groups of diversions, it may request the State Water Board to consider whether to require screening or other measures through the water right process. Alternatively, DFG may choose to require screening through its own regulatory processes. In addition, as the State Water Board evaluates water right compliance in the Bay-Delta watershed, it may consult with DFG on the need for screening and related issues. In an effort to

better understand the effects that unscreened diversions have on native and migratory fish, staff recommends that the State Water Board actively pursue the activity identified in the Bay-Delta Strategic Workplan: to work with the fisheries agencies to further evaluate these issues, (potentially as part of a monitoring program).

Concerns related to mortality from the SWP and CVP export facilities in the southern Delta should focus not just on screening but rather comprehensively on the specific locations, timing, magnitude, and methods of diversion. Regardless of whether the SWP and CVP export facilities in the Delta are screened, the current dead-end location, magnitude, and timing of these diversions would continue to draw large numbers of fish and other aquatic species to these locations where chances of survival are very low due to predation, poor habitat conditions, and related factors. The State Water Board, however, may wish to defer dedicating significant resources toward establishing screening requirements at the existing location because of concerns related to sea level rise and levee stability that could have a major long-term impact on their continued operation. The State Water Board should carefully evaluate the specific design (including fish screening) and operations of potential alternate diversion facilities to assure the protection of fish and wildlife beneficial uses as part of its water quality planning and water right processes. Staff also recommends that the State Water Board consider issues related to location, timing, magnitude, and methods of diversion in its review of export/inflow objectives and in the program of implementation for the export/inflow objectives. Any such consideration could help determine whether additional measures may be needed to address SWP and CVP export facilities in the Delta in the interim (if and until any new facilities are constructed), and in the long-term, to the extent the existing facilities are planned to continue operating.

Biological Indicators

Issue: Establishing biological indicators or triggers as water quality objectives for the protection of fish and wildlife beneficial uses in the Bay-Delta.

Staff Recommendation: Staff does not recommend that the State Water Board consider setting biological indicators or triggers as water quality objectives as part of its review and potential amendment of the Bay-Delta Plan. Rather, the State Water Board should consider available biological indicators or triggers, as well as other physical or chemical indicators, when considering the establishment or update of numeric flow or flow-related objectives in the Bay-Delta Plan.

Discussion: The biotic condition of an ecosystem is one important measure of overall ecological condition and environmental health, and provides useful information for environmental decision-making. Biological indicators are one of several attributes within an ecosystem that may be measured to provide environmental health information. To ascertain ecologic condition, other indicators such as chemical, physical, hydrologic and geomorphologic, and natural disturbance regimes may be used conjunctively.

Biological indicators are numerical values derived from actual measurements and have known statistical properties. The presence, condition, and numbers of the types of fish, insects, algae, plants and other aquatic life can provide accurate information about the health of a specific water body such as a river, stream, lake, wetland, or estuary. Assessing the condition of biological communities provides a basis both to determine ecological potential (managing the water body to achieve the ecological conditions that can be achieved given the changed conditions) and to measure success in achieving that potential. As such, biological indicators

and data can help set protection or restoration goals, determine what to monitor, interpret what is found, prioritize stressors, and assess and report the effectiveness of management actions (US EPA 2002).

Currently there is only one objective that uses only a biological indicator in the Bay-Delta Plan. The narrative Salmon Protection objective states "water quality conditions shall be maintained, together with other measures in the watershed, sufficient to achieve a doubling of natural production of Chinook salmon from the average production of 1967-1991, consistent with the provisions of State and federal law." The State Water Board did not require specific actions to implement the narrative objective because it expected that the objective would be effected through implementation of numeric flow-dependent objectives and other non-flow measures.

In the Delta, pelagic fish such as delta smelt are used as indicator species whose abundance may reflect the overall health of the ecosystem. Metrics used to help ascertain the health of the estuary include abundance, distribution, and diversity of fish and wildlife. Metrics related to aquatic habitat such as food production and use by indicator species are also important and are often paired with population measurements, especially when new or restored habitat is needed for the restoration of a fishery.

One limitation of setting objectives using only biological indicators is that measured impacts are often a result of multiple factors. Uncertainty regarding the predominant cause of a particular impact can lead to difficulty in reaching consensus on management plans, and make implementation difficult. In other words, using biological indicators as enforceable objectives is complicated by the fact that the interaction of environmental attributes can result in different changes in the system depending on the variables. For example, in the Delta, freshwater flow and other factors may combine to contribute to mechanisms for population responses to flow (Kimmerer 2002). Moreover, determining what actions should be taken if the objective is not met can be difficult.

There are many challenges associated with assessing the health of the Bay-Delta ecosystem due to chemical, physical and biological complexities (Jassby et al. 1995). The POD exemplifies these challenges. Since 2004, the IEP POD work team has identified many factors that may have contributed to the POD including: (1) mismatch of larvae and food; (2) reduced habitat space; (3) adverse water movement/transport; (4) entrainment; (5) toxic effects on fish; (6) toxic effects on fish food items; (7) harmful *Microcystis aeruginosa* blooms; (8) *Corbula amurensis* effects on food availability; and (9) disease and parasites. The IEP has focused its effort on three main factors; water management operations (diversions), invasive species, and toxicity problems in the Delta. However, uncertainty remains with respect to the magnitude of each of these effects on the POD. The IEP has only just begun to look at how stressors act upon a species, as well as considering how stressors may interact in their effects on each species (Baxter et al. 2008a). It may not be possible to establish biological indicators as meaningful objectives without adequate understanding of the relative importance of multiple complex stressors.

A prime example of just one complex stressor related to the POD is invasive species in the Delta and their associated ecosystem effects. Invasive species have caused a decline in estuarine health by altering both the top-down (consumer controlled) and bottom-up (producer controlled) structure; in part because of overgrazing by the invasive clam *Corbula* on phytoplankton, thus reducing the amount of food available to Delta fishes (Baxter et al. 2008a). The large clam population increases have also led to a higher selenium contamination in the benthic food web due to the bivalve's ability to bioaccumulate selenium quickly and lose it slowly

(Linville et al. 2002). Numerous complexities such as these add to the challenges of regulating based on biological indicators, if such an approach was to be considered.

Using biological indicators as objectives may have the unintentional effect of inadequately protecting beneficial uses. Whereas numeric objectives for chemical and physical parameters (e.g. flow) can be used to establish the conditions that are critical to the protection and enhancement of the ecosystem, biological indicators protect the indicator itself, which may also protect the ecosystem at large. When there is non-compliance with the indicator objective two compounding issues arise. First, the reason for non-compliance may be due to either of two factors: (1) the chemical and/or physical conditions needed for the indicator were not sufficient or realized within the system; or (2) some unknown factor other than a chemical or physical condition has caused the decline in the indicator (e.g. unforeseen invasive species or disease). The second issue is that once compliance becomes an issue, the effect on the indicator (objective) has already occurred and may be difficult if not impossible to reverse. As such, objectives based on chemical or physical conditions necessary to protect the ecosystem may be more desirable because they can be used to manage the system to a desired state predicted to protect beneficial uses, and control the conditions of greatest importance to the ecosystem while also recognizing that some factors are beyond control.

Therefore, a preferable approach would be to use all available physical, chemical and biological information in establishing flow and flow-related objectives for the protection of fish and wildlife beneficial uses. Studies indicate that biota of the San Francisco estuary may have one of the strongest and most consistent responses to flow among estuaries examined (Kimmerer 2004). By setting numeric flow objectives based on the State Water Board's understanding of biological indicators, the board would be able to address a variety of different fish and wildlife beneficial uses, which may help to restore declining Delta fish populations.

A key benefit of using biological indicators is that they can help measure overall ecosystem integrity and are a direct assessment of biological health. In addition, they can integrate effects of multiple stressors, are useful for trend analyses, and can identify unknown sources of stress. Delta outflow objectives are based on statistically significant relationships between fish species abundance and distribution, and Delta outflow. Although important, outflow is only one of many factors related to fishery health in the Delta. Staff believes it is important to continue to include using biological indicators and metrics in any flow-related objectives for the Delta. Establishment of flow objectives should be based on a variety of indicators (including those for other essential attributes). This will allow for integration of complicated drivers that affect multiple individual species, and protection of a wide variety of fish and wildlife beneficial uses.

Conclusion: Staff does not recommend establishing specific biological indicators or triggers as enforceable water quality objectives in light of the following factors: (1) the biological complexity within the estuary; (2) a need to consider indicators for other essential attributes and functions; (3) multiple causes of declines in estuarine species; (4) multiple causes in the decline of habitat; and (5) the interaction between the complexities above and the causes themselves. With respect to the decline of conditions within the Bay-Delta, it is important to gather more information on each specific driver before using biological indicators as objectives. For these reasons, staff recommends using biological and other indicators (e.g. ecological indicators) to: (1) inform the process of setting numeric flow and flow-related objectives; (2) evaluate the efficacy of numeric flow and flow-related objectives; and (3) use as triggers for defining when and how a numeric objective is applied, to facilitate adaptive management.

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VI. APPENDIX A

Periodic Review Comments	Responses	Plan Element Recommended for Further Review in Basin Planning Process
Bay-Institute		
Restoring the natural salinity variability of the Bay-Delta estuary is desirable, but should be based on historical conditions and organism tolerance ranges.	See Delta outflow section.	Yes
Freshwater flows continue to be the most strongly evidenced driver of ecological conditions in the Bay-Delta estuary, and the most reliable tool for protecting estuarine species and habitats.	See Delta outflow and San Joaquin River flow sections. Reviewing river flow requirements on the Sacramento River at Rio Vista may also be considered as part of the review of the Delta Outflow objectives. Tributary flows (other than San Joaquin River) upstream of the Bay-Delta are not recommended to be included as part of the Bay-Delta Plan review, but could instead be considered during separate water right proceedings.	Yes
Eliminating or reducing the adverse effects on Bay-Delta species and habitat quality of the deficient fish screens at the state and federal water project pumping facilities are the first priority, before screening unscreened diversions.	See fish screens section.	No
Biological objectives should be considered by the Board as a tool for improving adaptive management and guiding the development of new management tools and permit conditions.	See biological objectives section.	No

Central Delta Water Agency (CDWA)		
The water quality objectives for fish and wildlife beneficial uses should be revisited.	The State Water Board intends to consider modification of the various water quality and flow objectives for the protection of fish and wildlife beneficial uses through its basin planning activities. Specifically, the Delta Outflow, Export/Inflow, and Delta Cross Channel Gate Closure objectives are recommended for further review in the Staff Report. Additional objectives for Old and Middle River Flows are also recommended for review. In addition, other existing or new objectives will also be considered if supported by available information.	Yes
The Implementation Plan needs to be modified to forthrightly address Term 91.	The State Water Board will take these comments under consideration when considering any modifications to the Program of Implementation for the Bay-Delta Plan.	Not explicitly, but will be considered.
Central Valley Clean Water Association (CVCWA)		
The application of salinity objectives to municipal wastewater dischargers without proper consideration and implementation of Water Code sections 13000 and 13241 must be evaluated.	The State Water Board will take these comments under consideration when considering any modifications to salinity objectives and the program of implementation for those objectives.	Yes
Any considerations of modifying the Bay-Delta Plan to address constituents of concern for drinking water quality should be deferred to the Central Valley Drinking Water Policy development process currently underway with the Central Valley Regional Water Board.	The Staff Report does not expressly address these constituents, but is consistent with the recommendation.	N/A
Community Clean Water Institute (CCWI)		
When modifying the Bay-Delta Plan, the State Water Board should use an approach that is sustainable to both the economy and the Delta's ecosystem. A peripheral canal could provide such an approach, but only if it is actively monitored and regulated by a government agency that is proactive and financially prepared to react to changes in the Delta.	These comments will be considered when the State Water Board considers any modifications to the Bay-Delta Plan.	N/A

Department of Fish and Game (DFG)		
The State Water Board should consider including acute and chronic water quality objectives for ammonia and other nutrients in the Bay-Delta Plan for the protection of fishery resources and primary production.	See ammonia section.	No
DFG supports the State Water Board's continuing effort to review the San Joaquin River flow objectives.	Comment noted.	Yes
The State Water Board should continue to participate in the development of the Bay Delta Conservation Plan (BDCP) and to consider mechanisms for initiating review of the Bay-Delta Plan when the BDCP is nearing completion in order to facilitate efficiency.	The State Water Board intends to continue to coordinate with BDCP and other agencies as appropriate and to work to provide the most efficient and effective protection of beneficial uses.	N/A
DFG continues to support the Water Board's efforts to develop a regional monitoring program.	Comment noted.	N/A
The Water Board should consider developing a more complete assessment of the numbers, impacts, and timing of agricultural diversions in the Delta.	The State Water Board will consider these comments when developing monitoring and assessment requirements for the Bay-Delta Plan.	Not explicitly, but will be considered
Department of Water Resources (DWR)		
DWR is undergoing many different processes and reserves comments on the Bay-Delta Plan until those processes are completed or near completion.	Comment noted.	N/A
The State Water Board should consider changing the compliance period for the chloride objective at Rock Slough from a calendar year basis to a water year basis, though there may not be a strong argument for such a change.	The State Water Board considered such a change in the review of the 1995 Plan, but did not receive adequate information to support such a change. If additional information becomes available on which to base such a change, the State Water Board will consider such information.	No
Once additional monitoring information is available and DWR, USBR, and CCWD have additional opportunity to negotiate, the State Water Board should consider modifying the compliance location for chloride objectives at Pumping Plant #1.	Once additional information is available and negotiations are completed, the State Water Board will consider whether modifications should be made to compliance location.	No

DWR recommends that the Program of Implementation for the X2 portion of the Delta Outflow objectives be modified to allow for short term, temporary deviations from operations when implementing the objectives.	The State Water Board will consider proposals by DWR or others for modifying implementation of the Delta outflow objectives as part of its basin planning activities.	Yes
DWR provided additional background and scheduling information concerning Suisun Marsh, the Franks Tract Project, Los Vaqueros Reservoir Expansion, and projects related to southern Delta salinity.	The State Water Board will consider this information in its planning activities.	N/A
Northern California Water Association (NCWA) and Sacramento Valley Water Users (separate comment letters with the same comments)		
The State Water Board should prepare several different sets of potential draft plan amendments or revised plans for consideration prior to adoption of a revised plan in compliance with CEQA.	Comment noted. The State Water Board will comply with all requirements of CEQA and other applicable statutes and regulations when preparing any revisions to the Bay-Delta Plan.	N/A
The State Water Board should recognize that the Bay-Delta Plan can not address all of the various stressors affecting the Bay-Delta.	Comment noted.	N/A
San Francisco Public Utilities Commission (SFPUC)		
SFPUC provided comments and questions regarding the previously planned fact finding hearings.	These comments do not pertain to periodic review of the Bay-Delta Plan.	N/A
San Joaquin River Group Authority (SJRGA)		
There needs to be a better alignment between X2 flow requirement and water availability tied to a San Joaquin River Basin type of Index.	The State Water Board will take these comments under consideration when reviewing the San Joaquin River flow objectives and their implementation.	Yes
X2 flow requirements from the San Joaquin River for February through June need to be eliminated because San Joaquin River flow does not contribute to Delta outflow.	The State Water Board will take these comments under consideration when reviewing the San Joaquin River flow objectives and their implementation.	Yes

The State Water Board should clarify the narrative objective for salmon protection on Table 3 in the Bay-Delta Plan. Specific recommendations include: defining production consistent with Fish & Game Code section 6911; specifying that the objective is a goal and not an absolute; the goal is for the entire basin; and requiring installation of the Head of Old River barrier for any requested change permit by DWR or USBR at the export pumps.	At this point, staff does not recommend that the State Water Board prioritize review of the salmon narrative objective, but instead focus on review of the quantitative flow and other water quality parameters that are intended to protect fish and wildlife beneficial uses. However, if supported by adequate information during the basin planning process, the State Water Board may consider potential modifications to the salmon narrative objective. Regarding the Head of Old River Barrier, upon receipt of any petition by DWR or USBR to change their permit/license conditions, the State Water Board will review the specific information concerning the request and will act in compliance with applicable statutes and regulations to ensure the protection of fish and wildlife (including consideration of whether to require installation of barriers or other measures).	No
The dissolved oxygen objective for the Stockton Deep Water Ship Channel should be revised to protect a warm water fishery from June 15 through September 15 since cold water fish are not present in the ship channel at those times.	These comments pertain to the Central Valley Regional Water Board's Water Quality Control Plan for the Sacramento and San Joaquin River Basins.	No
San Luis and Delta Mendota Water Authority (SLDMWA) and Westlands Water District (WWD)		
The State Water Board should work with other ongoing planning efforts to address issues in the Bay-Delta. The Board should approach the periodic review of the Bay-Delta plan in two phases with the first phase focused on interim changes to the plan and the second phase focused on longer-term changes.	Comment noted. The State Water Board intends to continue to coordinate its work with other planning efforts, as appropriate.	N/A

When reviewing the Bay-Delta Plan, the State Water Board should conduct analyses to measure the benefits and costs of the various objectives. The Board should also consider increasing the flexibility of the objectives in order to allow for more protection at a lower cost.	Comment noted.	Not explicitly, but will be considered
Stockton East Water District (SEWD)		
The State Water Board should extend the salinity objectives for the San Joaquin River at Vernalis upstream to also apply between the Newman Wasteway and Vernalis in order to protect beneficial uses in this reach and reduce impacts to storage in New Melones Reservoir.	The State Water Board is actively coordinating with the Central Valley Regional Water Board to establish salinity objectives upstream of Vernalis. While this work has been delayed in the past, resources to complete this work have been secured by the Regional Board and work is expected to progress in a timely manner on this issue in coordination with the State Water Board's review of the southern Delta salinity objectives.	No
United States Department of the Interior (DOI)		
The State Water Board should review the following elements of the Bay-Delta Plan following completion of biological opinions for delta smelt and listed salmonids and green sturgeon due to fisheries issues, water supply issues, or potential beneficial use conflicts:	Responses to the corresponding numbered recommendations are provided below:	
1. Water quality compliance and baseline monitoring program	1. Recommended for review	1. Yes
2. Chloride objectives, compliance location at Contra Costa Pumping Plant #1, and potential new objectives	2. Please see response to DWR comment above.	2. No
3. Export limits objectives	3. Recommended for review	3. Yes
4. Delta Cross Channel gates closure objective	4. Recommended for review	4. Yes
5. Salmon protection objective	5. Please see response to SJRGA comment above	5. No
6. Delta outflow objectives	6. Recommended for review	6. Yes
7. River flow objectives: Sacramento River at Rio Vista	7. Please see response to Bay-Institute comment above	7. No
8. River flow objectives: San Joaquin River at Airport Way Bridge, Vernalis, Spring Flow objectives for February - April 14 and May 16 - June	8. Review underway	8. Yes

9. River flow objectives: San Joaquin River at Airport Way Bridge, Vernalis, 31-day Pulse Flow objectives for April 15 – May 15	9. Review underway	9. Yes
10. Southern Delta Electrical Conductivity objectives	10. Review underway	10. Yes
11. Relevant parts of the Program of Implementation for each of the above	11. Recommended for review	11. Yes

Fact Finding Comments	Responses
This section summarizes and responds to comments received as part of the State Water Board's previously proposed Fact Finding proceeding related to Periodic Review of the Bay-Delta Plan. Due to the cancellation of that proceeding, responses are only provided to comments that potentially relate to Periodic Review of the Bay-Delta Plan.	
California Farm Bureau Federation (CFBF)	
The CFBF provided recommended clarification of fish screening and ammonia fact finding topics.	To the extent this comment pertains to Periodic Review of the Bay-Delta Plan, see the fish screens and ammonia sections regarding the State Water Board's consideration of these issues as related to the Periodic Review.
The CFBF recommended addition of the following topics for the fact finding proceedings: invasive species, temperature, predation, alteration in food web dynamics, turbidity and other physical factors of the water column, and exogenous factors such as climate change, ocean conditions, and drought cycles.	This comment is primarily related to the fact finding proceedings. To the extent this comment is related to the Periodic Review they were considered in development of the Staff Report and will be considered as appropriate in other Water Board processes.
Central Delta Water Agency (CDWA)	
CDWA recommended that the State Water Board hold fact finding proceedings to quantify the impacts of CVP and SWP facilities and operations on the Bay-Delta ecosystem and quantification of what flow, water quality and other requirements are needed to fully mitigate those impacts.	To the extent this comment pertains to Periodic Review of the Bay-Delta Plan, it was considered in preparation of the Periodic Review Staff Report and will be considered as appropriate in other Water Board processes.
Central Valley Clean Water Association (CVCWA)	
CVCWA recommended that the State Water Board include invasive species as a fact finding topic.	To the extent this comment pertains to Periodic Review of the Bay-Delta Plan, it was considered in preparation of the Periodic Review Staff Report and will be considered as appropriate in other Water Board processes.
CVCWA recommended that the State Water Board include fish entrainment by CVP and SWP diversions as a fact finding topic.	To the extent this comment pertains to Periodic Review of the Bay-Delta Plan, see the fish screens and export/inflow sections.

CVCWA recommended that the State Water Board include nutrient management and potential advantages and disadvantages of nutrient source control that may be harmful to the foodweb in its fact finding proceedings.	To the extent this comment pertains to Periodic Review of the Bay-Delta Plan, see the ammonia section.
CVCWA recommended that the State Water Board consider DSM2 modeling when evaluating potential impacts of waste-water treatment plants as a source of salinity into the Delta.	To the extent this comment pertains to Periodic Review of the Bay-Delta Plan, see the southern Delta salinity section.
Contra Costa Water District (CCWD)	
CCWD recommended that the State Water Board review historical salinity variability and fish abundance in the Delta before conducting fact finding proceedings related to the effects of constant or variable salinity on the estuary. CCWD provided information related to these issues and identified additional information that it will provide.	To the extent this comment pertains to Periodic Review of the Bay-Delta Plan, see the Delta outflow section.
County of Sacramento & Sacramento County Water Agency (Sac. County)	
Sac. County commented that the State Water Board must consider Area of Origin protections and the water right priority system when addressing potential future impacts of water diversions and outflow objectives.	Comment noted. To the extent this comment pertains to Periodic Review of the Bay-Delta Plan, see the Program of Implementation section.
Sac. County commented that the scope of the Bay-Delta Plan and D-1641 are amended. The fact finding hearings were too limited and the State Water Board should also look at potential terrestrial effects, local Delta communities, and economic effects.	This comment is primarily related to the fact finding proceedings. To the extent this comment is related to the Periodic Review, they were considered in development of the Staff Report and will be considered as appropriate in other Water Board processes.
Sac. County specifically recommended not using any Sacramento County storm drain data in its fact finding proceedings and instead recommended relying on monitoring data from the Delta.	Comment Noted.
Department of Fish and Game (DFG)	
DFG recommended that the State Water Board consider issues related to San Joaquin River flows as a fact finding hearings topic.	To the extent this comment pertains to Periodic Review of the Bay-Delta Plan, see the San Joaquin River Flow section.
DFG recommended that the State Water Board use the San Joaquin Chinook Salmon Population Escapement Model to assess the adequacy of the San Joaquin River flow objectives.	Comment noted. To the extent this comment pertains to Periodic Review of the Bay-Delta Plan, see the San Joaquin River flow objectives section.

Department of Water Resources (DWR)	
DWR recommended that sources of salinity to the southern Delta be a high priority for the fact finding proceedings and that no additional work on salinity take place until the Bay-Delta Plan and D-1641 are amended.	To the extent this comment pertains to Periodic Review of the Bay-Delta Plan, see the southern Delta salinity section.
DWR recommended not holding fact finding proceedings on the biological impacts of constant or variable salinity and Delta outflows until various Endangered Species Act processes are completed. DWR stated that the State Water Board's involvement in this issue would disrupt the BDCP process which is currently involved in addressing these issues.	To the extent this comment pertains to Periodic Review of the Bay-Delta Plan, see the Delta Outflow section. The State Water Board will continue to coordinate with other ongoing related processes on this and other related Bay-Delta issues as needed.
DWR recommended that the State Water Board conduct a study on the effects of fish screens on pelagic organisms and then, if necessary, hold fact finding proceedings on this subject with opportunity for potentially affected parties to participate.	To the extent this comment pertains to Periodic Review of the Bay-Delta Plan, see the fish screens section.
DWR recommended that ammonia be one of the first issues the State Water Board address when amending the Bay-Delta Plan and recommended that the Central Valley Regional Board provide information related to this issue.	To the extent this comment pertains to periodic review of the Bay-Delta Plan, see the ammonia section. The State Water Board will continue to coordinate with the Central Valley Regional Water Board on this and other related Bay-Delta issues as needed.
DWR recommended that toxicity be given a high priority in the fact finding proceedings.	To the extent this comment pertains to periodic review of the Bay-Delta Plan, see the toxicity section.
San Luis & Delta-Mendota Water Authority, Westlands Water District, State Water Contractors & Kern County Water Agency (Contractors)	
The Contractors recommended that specific issues related to sources of salinity be investigated in the fact finding proceedings.	To the extent this comment pertains to periodic review of the Bay-Delta Plan, see the southern Delta salinity section.
The Contractors recommended that fish screens be investigated in the fact finding proceedings.	To the extent this comment pertains to periodic review of the Bay-Delta Plan, see the fish screens section.
The Contractors provided a list of 10 additional issues recommended for investigation in the fact finding proceedings including impacts of:	Responses to the corresponding numbered recommendations are provided below:
1. CVP/SWP diversions	1. To the extent this comment pertains to periodic review of the Bay-Delta Plan, see the exports/inflow and fish screens sections.
2. Changes in temperatures	2. To the extent this comment pertains to periodic review of the Bay-Delta Plan, to the extent appropriate, this issue will be considered in the review of other objectives.

3. Changes in turbidity	3. To the extent this comment pertains to periodic review of the Bay-Delta Plan, to the extent appropriate, this issue will be considered in the review of other objectives.
4. Endocrine disruptors	4. To the extent this comment pertains to periodic review of the Bay-Delta Plan, see the toxicity section.
5. Dredging	5. This issue is and will continue to be addressed through other Water Board processes.
6. Changes in net Delta outflow	6. To the extent this comment pertains to periodic review of the Bay-Delta Plan, see the Delta outflow section.
7. Changes in export/inflow ratio	7. To the extent this comment pertains to periodic review of the Bay-Delta Plan, see the export/inflow section.
8. Suisun Marsh salinity management	8. To the extent this comment pertains to periodic review of the Bay-Delta Plan, Bay-Delta Plan and D-1641 are amended, see the Suisun Marsh section.
9. Toxics	9. To the extent this comment pertains to periodic review of the Bay-Delta Plan, see the ammonia and toxicity sections.
10. Invasive species	10. This issue is and will continue to be addressed through other Water Board processes.
East Bay Municipal Utility District (EBMUD)	
EBMUD recommended that the State Water Board conduct fact finding proceedings on the effects of ocean conditions on the Bay-Delta.	To the extent this comment is related to Periodic Review of the Bay-Delta Plan, since the State Water Board does not have direct regulatory authority over this issue, the State Water Board will consider this issue as appropriate when providing recommendations to other agencies in the Program of Implementation.
Stockton East Water District (SEWD)	
SEWD recommended that the State Water Board conduct fact finding proceedings on ocean conditions and harvesting of fisheries.	To the extent this comment is related to Periodic Review of the Bay-Delta Plan, since the State Water Board does not have direct regulatory authority over this issue, the State Water Board will consider this issue as appropriate when providing recommendations to other agencies in the Program of Implementation.

SEWD recommended that Bay-Delta Plan and D-1641 are amended and that the State Water Board hold a hearing soliciting information regarding the state of non-native species in the Bay-Delta and the effect of these species on native fishery population.	To the extent this comment is related to Periodic Review of the Bay-Delta Plan, this issue will be considered in review of other objectives, including Delta outflow. However, it is not recommended for review as a stand alone issue, but instead will be addressed through other efforts by the Water Boards and other agencies.
SEWD recommended that the Board hold a hearing on sources of salt to the Delta.	To the extent this comment pertains to periodic review of the Bay-Delta Plan, see the southern Delta salinity section.
San Joaquin River Exchange Contractors (Exchange Contractors)	
The Exchange Contractors recommended a fact finding proceeding on: 1. The effects and impacts of application of the Endangered Species Act on the operations of California's water storage and delivery system. 2. The benefits and detriments of an alternative procedure in lieu of the current procedure of issuing biological opinions. 3. The subject of flow and temperature requirements on the Yuba, Feather, and Sacramento Rivers in order to determine if fisheries are showing greater survivability and returning adults than streams without these requirements.	Comment noted.
Northern California Water Association (NCWA)	
No comments related to periodic review.	
California Water Impact Network and the California Sportfishing Protection Alliance (C-WIN & CSPA)	
CSPA recommended that the State Water Board re-regulate export pumps by taking the following steps:	Responses to the corresponding numbered recommendations are provided below:
1. Provide fish passage at Central Valley Watershed Rim Dams	To the extent this comment pertains to periodic review of the Bay-Delta Plan, this issue is not proposed for review. However, the State Water Board may consider this issue as appropriate in its other water right and water quality activities.
2. Dedicate reservoir storage as cold water habitat for endangered fish	Same as above.
3. Change hourly reservoir flow releases and prevent additional depletion of reservoir storage that impacts salmon and steelhead	Same as above.
4. Change temperature of reservoir flow releases to provide cold water for fish trapped below project dams that are exposed to unnaturally high water temperatures	Same as above.

5. Establish additional cold water reservoir storage	Same as above.
6. Evaluate water quality in rivers leading into the Bay-Delta	6. The State Water Board will continue to coordinate with the Central Valley Regional Water Board on this and other related Bay-Delta issues as needed.
7. Evaluate biological effects of salinity in the Bay-Delta	7. To the extent this comment pertains to periodic review of the Bay-Delta Plan, see the southern Delta salinity section.
8. Establish salinity objectives upstream of Vernalis	8. To the extent this comment pertains to periodic review of the Bay-Delta Plan, see the southern Delta salinity section. The State Water Board will continue to coordinate with the Central Valley Regional Water Board's effort to establish salinity objectives upstream of Vernalis.
9. Establish interim X2 Bay-Delta fall outflow requirements for all year conditions	9. To the extent this comment pertains to periodic review of the Bay-Delta Plan, see the Delta outflow section.
10. Determine biological effects of project pumping	10. To the extent this comment pertains to periodic review of the Bay-Delta Plan, see the exports/inflow and fish screens sections.
11. Establish effective fish screens at project pumping facilities in the Bay-Delta	11. To the extent this comment pertains to periodic review of the Bay-Delta Plan, see the fish screens section.
12. Determine whether the head of Old River barrier is in or out in the future	12. Comment noted.
13. Establish inflow-outflow weekly ratio for all weeks of the year	13. To the extent this comment pertains to periodic review of the Bay-Delta Plan, see the Delta outflow and exports/inflow sections.
14. Evaluate cross channel gate and Suisun Marsh salinity control gate operations	14. To the extent this comment pertains to periodic review of the Bay-Delta Plan, see the Delta Cross Channel Gate and Suisun Marsh sections.
15. Prevent Bay-Delta operational effect on the Trinity and other rivers	15. These comments will be considered when the State Water Board considers any modifications to the Bay-Delta Plan.
Sacramento Regional County Sanitation Distric (SRCSD)	
SRCSD requested that the State Water Board address the following issues in this order during its fact finding proceedings:	
1. Export pump fish screen entrainment	1. To the extent this comment pertains to periodic review of the Bay-Delta Plan, see the fish screens section.
2. Net Delta outflows	2. To the extent this comment pertains to periodic review of the Bay-Delta Plan, see the Delta outflow section.

3. Invasive species	3. To the extent this comment is related to Periodic Review of the Bay-Delta Plan, this issue will be considered in review of other objectives, including Delta outflow. However, it is not recommended for review as a stand alone issue, but instead will be addressed through other efforts by the Water Boards and other agencies.
4. Salt loading	4. To the extent this comment pertains to periodic review of the Bay-Delta Plan, see the southern Delta salinity objectives section.
5. Salt biological impacts	5. See Delta outflow section.
6. Ammonia	6. To the extent this comment pertains to periodic review of the Bay-Delta Plan, see the ammonia section.
7. Toxic substances	7. To the extent this comment pertains to periodic review of the Bay-Delta Plan, see the toxicity section
8. Fish screens in the Delta	8. To the extent this comment pertains to periodic review of the Bay-Delta Plan, see the fish screens section.
9. Nutrients	9. The State Water Board will continue to coordinate with the Central Valley Regional Water Board on this and other related Bay-Delta issues as needed.
SRCSD also provides specific information on studies it recommends the State Water Board review as related to export fish screen entrainment, invasive species, ammonia, and nutrients.	Noted.
San Joaquin River Group (SJRG)	
SJRGA recommended that San Joaquin River flows be a subject of the fact finding hearings. SJRG proposed various facts and issues the Board will need to address to establish San Joaquin River flow objectives, including competing reasonable and beneficial uses, and the factors affecting fall-run chinook salmon smolt survival through the Delta.	Bay-Delta Plan and D-1641 are amended. To the extent this comment pertains to periodic review of the Bay-Delta Plan, see the San Joaquin River flows section.
City of Antioch (Antioch)	
Antioch referred to an analysis of historic salt water intrusion and its impacts to the Bay-Delta, related to net outflow objectives for consideration in the fact finding proceedings.	Comment noted. To the extent this comment pertains to periodic review of the Bay-Delta Plan, see the Delta outflow section.

Antioch commented that Bay-Delta Plan and D-1641 are amended. It is critical to consider the source of water in the central and western Delta, including the inflow of tributaries, such as the Mokelumne and Sacramento Rivers to the western San Joaquin River, which control salinity and water quality in the western and south Delta.	Comment noted.
Antioch recommended that the State Water Board consider the significant adverse impacts on fish and the environment if Sacramento River flows into the San Joaquin River are reduced by anticipated upstream projects.	Comment noted.
South Delta Water Agency (SDWA)	
SDWA commented that the State Water Board should determine the extent to which new and additional regulation is necessary to address the effects of the SWP and CVP on the fisheries and the Delta ecosystem.	To the extent these comments pertain to Periodic Review of the Bay-Delta Plan, these comments will be considered when the State Water Board considers any modifications to the Bay-Delta Plan.
SDWA recommended that the State Water Board hold a fact finding hearing to determine how much Delta outflow is necessary, and when it should be made available in order to protect fishery beneficial uses since current levels are not adequate.	To the extent these comments pertain to Periodic Review of the Bay-Delta Plan, see the Delta outflow section.
SDWA recommended that the State Water Board conduct fact finding proceedings on exports to address fisheries concerns from historically high exports.	To the extent these comments pertain to Periodic Review of the Bay-Delta Plan, see the export/inflow section.
SDWA comments that the examination of what is needed to protect fishery beneficial use needs (and other beneficial use needs) should include a determination of the amount of water needed to supply areas of origin and Delta Protection Act needs.	To the extent these comments pertain to Periodic Review of the Bay-Delta Plan, they will be considered when the State Water Board considers modifications to the Bay-Delta Plan.
United States Department of the Interior (Interior)	
Interior voiced support for conducting fact finding proceedings on the previously proposed list of fact finding issues.	All of the previously proposed fact finding topics are addressed in this Staff Report. For information about specific issues, see the individual sections.

CALIFORNIA
Water Boards

STATE WATER RESOURCES CONTROL BOARD

REGIONAL WATER QUALITY CONTROL BOARDS

Office of Public Affairs: (916) 341-5254
Office of Legislative Affairs: (916) 341-5251

Financial Assistance information: (916) 341-5700
Water Quality information: (916) 341-5455
Water Rights information: (916) 341-5300

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARDS

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www.waterboards.ca.gov/northcoast
5550 Skylane Blvd., Suite A
Santa Rosa, CA 95403
info1@waterboards.ca.gov
(707) 576-2220 TEL • (707) 523-0135 FAX

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1515 Clay Street, Suite 1400
Oakland, CA 94612
info2@waterboards.ca.gov
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CENTRAL COAST REGION (3)
www.waterboards.ca.gov/centralcoast
895 Aerovista Place, Suite 101
San Luis Obispo, CA 93401
info3@waterboards.ca.gov
(805) 549-3147 TEL • (805) 543-0397 FAX

LOS ANGELES REGION (4)
www.waterboards.ca.gov/losangeles
320 W. 4th Street, Suite 200
Los Angeles, CA 90013
info4@waterboards.ca.gov
(213) 576-6600 TEL • (213) 576-6640 FAX

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www.waterboards.ca.gov/centralvalley
11020 Sun Center Drive, Suite 200
Rancho Cordova, CA 95670
info5@waterboards.ca.gov
(916) 464-3291 TEL • (916) 464-4645 FAX

Fresno branch office
1685 E Street, Suite 200
Fresno, CA 93706
(559) 445-5116 TEL • (559) 445-5910 FAX

Redding branch office
415 Knollcrest Drive
Redding, CA 96002
(530) 224-4845 TEL • (530) 224-4857 FAX

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www.waterboards.ca.gov/lahontan
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South Lake Tahoe, CA 96150
info6@waterboards.ca.gov
(530) 542-5400 TEL • (530) 544-2271 FAX

Victorville branch office
14440 Civic Drive, Suite 200
Victorville, CA 92392
(760) 241-6583 TEL • (760) 241-7308 FAX

COLORADO RIVER BASIN REGION (7)
www.waterboards.ca.gov/coloradoriver
73-720 Fred Waring Dr., Suite 100
Palm Desert, CA 92260
info7@waterboards.ca.gov
(760) 346-7491 TEL • (760) 341-6820 FAX

SANTA ANA REGION (8)
www.waterboards.ca.gov/santaana
California Tower
3737 Main Street, Suite 500
Riverside, CA 92501-3339
info8@waterboards.ca.gov
(951) 782-4130 TEL • (951) 781-6288 FAX

SAN DIEGO REGION (9)
www.waterboards.ca.gov/sandiego
9174 Sky Park Court, Suite 100
San Diego, CA 92123
info9@waterboards.ca.gov
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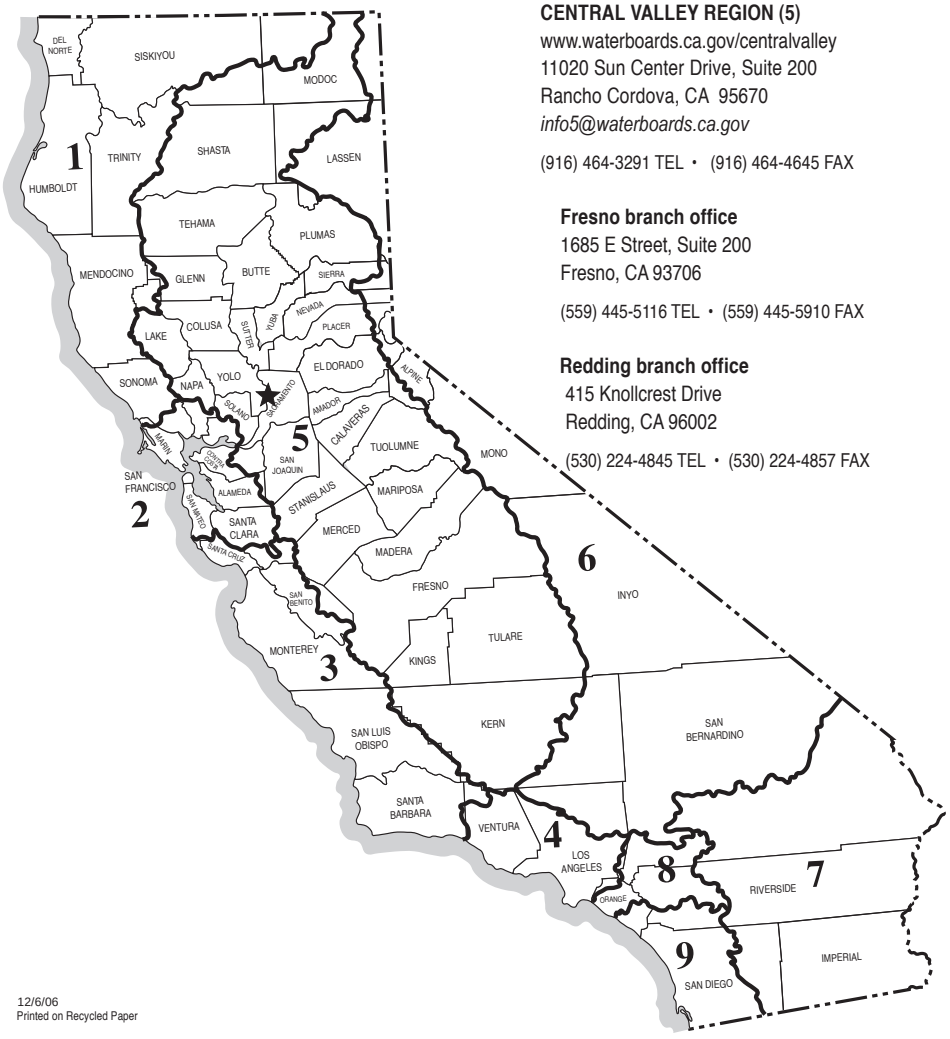

★ **State Water Resources Control Board** (Headquarters)
1001 I Street, Sacramento, CA 95814

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California Environmental Protection Agency
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