

Delta Science Program Independent Review Panel Report

BDCP Effects Analysis Review, Phase 1

Ale Parker, Ph D, California State University Panel Chair
Charles Si Si enstad, S, university of Washington lead Author
Mike George, Ph D, Colorado State University
Nancy Conson, Ph D, Stanford University
Joe Parker, Ph D, California State University San Francisco
Greg Ruggerone, Ph D, Natural Resources Consultants, Inc
John Skalski, Ph D, University of Washington

Delta Science Program Independent Review Panel Report: BDCP Effects Analysis Review, Phase 3

Table of Contents

Executive Summary	5
1. How well does the Effects Analysis meet its expected goals?	6
2. How complete is the Effects Analysis; how clearly are the methods described?	7
3. Is the Effects Analysis reasonable and scientifically defensible? How clearly are the net effects results conveyed in the text, figures and tables?	7
4. How well is uncertainty addressed? How could communication of uncertainty be improved?	8
5. How well does the Effects Analysis describe how conflicting model results and analyses in the technical appendices are interpreted?	8
6. How well does the Effects Analysis link to the adaptive management plan and associated monitoring programs?	8
Introduction	10
Background and History	10
BDCP Goals and Role of Effects Analysis	10
Panel Members	11
Charge to Panel	11
Review Schedule	11
Organization of Report	12
Summary observations	12
Responses to Phase 1 and Phase 2 Panel recommendations	12
Accessibility of Effects Analysis elements	16
General Charge Questions	16
1. How well does the Effects Analysis meet its expected goals?	16
2. How complete is the Effects Analysis; how clearly are the methods described?	20
3. Is the Effects Analysis reasonable and scientifically defensible? How clearly are the net effects results conveyed in the text, figures and tables?	24

4.	How well is uncertainty addressed? How could communication of uncertainty be improved?	35
5.	How well does the Effects Analysis describe how conflicting model results and analyses in the technical appendices are interpreted?	38
6.	How well does the Effects Analysis link to the adaptive management plan and associated monitoring programs?	41
Review of Specific Analyses		44
7.	Are the analyses related to the North Delta Diversion facilities appropriate and does the Effects Analysis reasonably describe the results? In particular:	44
8.	How should the effects of changes in Feather River flows on fish spawning and rearing be characterized? In particular, how should the trade-off between higher spring flows and lower summer flows be interpreted? Does the analysis adequately capture the expected benefits of CM 2, Yolo Bypass Fishery Enhancement?	49
9.	Does the analysis adequately describe the predation and other screen-related effects of the proposed North Delta Diversion structures? Is the application of the observed mortality rate at the fish screen of the Glenn-Colusa Irrigation District (GCID) an appropriate assumption for expected mortality at the proposed BDCP north Delta intakes? Are there other studies on salmonid survival at positive barrier fish screens that would be appropriate to apply? ...	51
10.	Does the Effects Analysis provide a complete and reasonable interpretation of the results of physical models as they relate to upstream spawning and rearing habitat conditions, particularly upstream water temperatures and flows resulting from proposed BDCP operations?	53
11.	Does the Effects Analysis use a reasonable method for "normalizing" results from the salvage-density method to the population level for salmonid species?	54
12.	Are the assumptions of the analysis of aquatic habitat restoration food web effects appropriate for covered fish species? Are the conclusions and net effects appropriate?	56
13.	Is the analysis of food web benefits to longfin smelt from habitat restoration appropriate? How well do the analyses link intended food web improvements to improvement in the longfin smelt spring Delta outflow/recruitment relationship?	60
14.	How well does the analysis address population-level effects of the BDCP on white sturgeon?	61
Adequacy of Technical Appendices		62
References Cited		76
Appendices		80
Appendix A—BDCP Effects Analysis Scientific Review Panel members biographies		80

Appendix B—Charge to the Delta Science Program Independent Review Panel for the BDCP Effects Analysis Review, Phase 3 (dated 2/12/2014).....	83
Appendix C—Observed tidal stage and flow time series data from three key locations along the Sacramento River (from BDCP Appendix 5A-D1, pp 128-129)	85
Appendix D—Variance Calculations Associated with Salvage Model.....	86

ist of ables

Table 1	Relative ranking of alternative model scenarios for medial adult escapement based on the IOS and OBAN models (1 = highest, 10 = lowest).....	71
---------	--	----

Executive Summary

Under the auspices of the Delta Science Program, the seven-member Independent Scientific Review Panel (Panel) reviewed the adequacy of the Effects Analysis component of the Bay Delta Conservation Plan (BDCP or Plan). This report represents the third phase of the Effects Analysis review; the Phase 1 (completed in November 2011) and Phase 2 reviews (completed June 2012) were partial reviews of the Effects Analysis and were completed as the Conceptual Foundation and Analytical Approach were still under development. These documents are available online at: <http://deltacouncil.ca.gov/science-program/independent-review-draft-bay-delta-conservation-plan-effects-analysis>. The present, Phase 3 review covers the first complete public draft of the BDCP Chapter 5 Effects Analysis and its associated technical appendices, made available in December 2013.

Four broad themes emerged from the Panel's review of the BDCP Effects Analysis. Firstly, the long, highly detailed document was difficult to review and comprehend. The vastness of the Effects Analysis report and appendices are both its strength and weakness. Although highly improved from the documents that the Panel reviewed during Phase 2, Chapter 5 continues to be fragmented in its presentation and sometimes inconsistent with the technical appendices. While the sheer scope of the analysis is impressive, the inefficient organization and incomplete cross-referencing among sections within the Effects Analysis (e.g., the 8 supporting appendices, totaling ~4500 pages) as well as with the larger BDCP planning documents make interpretation of anticipated net effects of BDCP implementation difficult at best. The 745-page Chapter 5: Effects Analysis does not represent a stand-alone document and it relies extensively on the associated appendices and other chapters for the presentation of scientific information, with insufficient guidance for the reader. As concluded from the Phase 2 report, the Panel universally believes that by itself, Chapter 5: Effects Analysis inadequately conveys the fully integrated assessment that is needed to draw conclusions about the Plan, in part because of incomplete information on factors affecting the covered species.

The second theme in the Panel's review is an apparent disconnect between the assessments of the levels of scientific uncertainty presented in Chapter 5 versus what is characterized in the technical appendices. In many cases, the Panel felt that there was appropriate characterization of high uncertainty within the technical appendices but Chapter 5 did not sufficiently acknowledge or articulate this reality, especially when using professional judgment to reach overall net effects of the BDCP on key species. In particular, the Panel observed that the critical uncertainties associated with presumed beneficial effects of tidal wetland restoration were not recognized in the Chapter 5 summary. Given the magnitude of the BDCP, the inherent natural and anthropogenic complexity in the Bay-Delta ecosystem, and the long time horizon for BDCP implementation and rehabilitated community development, most of the potential BDCP effects carry a relatively high level of uncertainty. For these reasons, the Effects Analysis must provide clear guidance for conceptual models, monitoring, metrics that assess underlying ecosystem processes, explicit thresholds and triggers, alternative hypotheses, special studies to address critical information gaps, and structured decision making in the form of a rigorously institutionalized adaptive

management process.

The third major theme of this review is the lack of an integrated or quantitative assessment of net effects, echoing a similar review comment in the Phase 2 review. The Panel acknowledges that considerable effort has been made in documenting the complex information used to determine net effects. However, in the case of covered species, effects could not be quantified and only two of the sixteen existing life cycle models were deemed to be relevant to BDCP. For these and other reasons, a systematic approach to synopsise the overall net effect on each species was not used. Instead, professional judgment was used instead of a ranking approach to quantify a synthesis of cumulative effects and associated certainty in the projected outcome. Finally, in one paragraph, Chapter 5 accurately portrayed the anticipated BDCP effects: *"These expectations represent a working hypothesis of the relationship between actions, stressors, and biological performance"*. However, this statement was not emphasized throughout the document.

The fourth major theme reflected on the need to address the extensive uncertainties associated with the assumptions and predictions of the beneficial effects of the BDCP conservation measures. While the Phase 2 Effects Analysis accurately reflected the detailed process and implementation structure to apply an adaptive management approach to resolve uncertainties, the Panel was concerned that it defaulted to rather "passive learning" instead of a rigorous, institutionalized adaptive management process that resolved effects on covered species and their requisite ecosystems through an active, experimental approach.

Together with background obtained during Phase 1 and 2 of the BDCP Effects Analysis review, the Panel provides the following synopsis of the Panel's responses to their General Charge Questions; further responses to specific issues and the adequacy of supporting documents are provided in the body of the report.

1. How well does the Effects Analysis meet its expected goals?

The Phase 3 review-version of the Effects Analysis is a much improved and impressive compilation of background material and scientific and technical knowledge about the Bay-Delta that provides a plausible basis for the conservation measures. The Panel concluded that much of the available data and arguments for the rationale behind the Effects Analysis assumptions and conclusions are contained within the BDCP documents. However, we suggest that the Effects Analysis (Chapter 5) itself is still poorly substantiated and leaves too much to appendices and other BDCP chapters without explicit cross-references. The lack of accessibility to information within the chapter or clear reference to supporting detail inhibits rather than elucidates comprehension of the findings and thus conveys an unsatisfying "trust us" message.

Our conclusion of the Effects Analysis is that many of the critical assumptions in modeling effects and justifications behind the supposed benefits of the conservation measures are highly uncertain. Much of the conservation measures center around restoration activities and management actions to improve current conditions. Our impression, therefore, is that the foundation of the BDCP is weak in many respects and the default burden to ensure covered species benefit, if not recovery, depends on adaptive management. The adequacy of the BDCP therefore rests not in the intent and development of the conservation measures, but in the rigor and application of

adaptive management to ensure that the critical uncertainties are addressed and strategically incorporated into a progressively refined Plan.

2. How complete is the Effects Analysis; how clearly are the methods described?

Chapter 5 provides a comprehensive overview of the spatial and temporal scope of the analysis, definitions of project baselines that differ depending on regulatory authority, recognition of climate change information, identification of a variety of models used to evaluate effects, treatment of viable salmon population criteria, and the approach to determining net effects on fish and wildlife. As might be expected, with the size of the Effects Analysis task, the quality of the assessments ranged in scientific rigor based on the amount of available data and best available science. Some aspects of the assessment, such as water quality and flow, were quantitatively assessed using sophisticated mathematical models. Some aspects of the Chinook salmon assessments were also based on empirical data and process-based models. However, for many of the other fish species and their potential stressors, conceptual models supported by the scientific literature were the only recourse.

3. Is the Effects Analysis reasonable and scientifically defensible? How clearly are the net effects results conveyed in the text, figures and tables?

The approach to net effect conclusions needs to be reconsidered and revamped. The Effects Analysis assessment of net effects, particularly for covered fish, tries to incorporate information on potentially beneficial or detrimental effects covering 12 different stressors, 32 attributes, and multiple life stages using best available information and science. Only a perfect life-cycle model with perfect information on all the effects and their interactions could possibly weight the results correctly and draw unambiguous conclusions. A serious limiting factor of the current consolidation of Net Effects is a near complete absence of any weighting of the biological importance to particularly sensitive life history stages of the many attributes under consideration. As a result, whether and how any critical life stages or attributes are being adversely affected by the BDCP is generally unclear. The net effects conclusions for a fish species needs to therefore take into account the relative importance of the various life history stages, make them explicit, and interpret Plan effects within that context on a species-by-species basis. Similarly, the simple summation of the number of acres of suitable habitat that are removed or restored for each species by the conservation measures does not consider landscape-level effects such as connectivity and patch size, nor does it take into account variation in habitat quality.

The net effects analysis tends to overreach conclusions of positive benefits for covered fish species, given the inability to quantify the over-all net effects and the realization of high uncertainty. In particular, it does not adequately defend conclusions regarding the net effects of habitat restoration. Restoration of tidal wetlands (and other communities) is highly uncertain and at least an extremely long process. The Effects Analysis does not adequately justify the critical assumption of the benefit of tidal wetland restoration as a food web subsidy for covered pelagic fish given the uncertainties of tidal wetland restoration itself. A critical issue is the implicit expectation that restoration activities will result in increases in abundance of lower trophic levels, but it is uncertain whether the resulting increased production will result in food web pathways supporting covered species. The presentation of phytoplankton-based and tidal wetland macrophyte

detritus-based food webs as alternative ecosystem processes, rather than as an integrated system, also significantly complicates the interpretation of the potential benefit of BDCP restoration. For foraging salmonids, the Effects Analysis did not evaluate the reduced extent to which salmonids would have access to rehabilitated habitat when the north Delta intakes are operating and flows are reduced.

Only one configuration of Restoration Opportunity Areas (ROAs) were modeled by the hydrodynamic models and the locations of these assumed Restoration Opportunity Areas are not available. Some details of the hydrodynamic modeling, especially where 1D and 2D models did not agree or situations where counter-intuitive results were reported, could not be evaluated due to the limited information provided.

4. How well is uncertainty addressed? How could communication of uncertainty be improved?

A broad consensus exists among the Panel that Chapter 5 does not adequately acknowledge the extensive uncertainty associated with the BDCP's assumptions and predictions. In its current form, at the level of detail conveyed, in the models used, and in the verbal assessments and conclusions, the level of uncertainty is often downplayed. Within appendices sometimes more explicit discussion of uncertainties can be found, but there is a disconnect between the summary pages with the conclusions drawn in Chapter 5. In situations in which an array of outcomes may be possible, only the more beneficial outcomes are used in conclusions about the BDCP. Communication of uncertainty would be improved by consideration of a range of potential outcome values in models.

5. How well does the Effects Analysis describe how conflicting model results and analyses in the technical appendices are interpreted?

The Panel found models describing salmonid Delta passage and habitat suitability for terrestrial species to be appropriate and any conflicting results adequately explained. Because hydrodynamic models are sensitive to how the open water regions are represented and how they are connected to the adjacent channels, and because the panel was not provided the bathymetric configuration of the ROAs or the order in which the ROAs were established, it is not feasible for the Panel to evaluate the sensitivity of the models to the placement of the Restoration Opportunity Areas.

Overall, the Panel found the Chapter 5 text describing the two life cycle models (IOS and OBAN), which provide alternative views of BDCP effects compared with other analyses, to be complicated and somewhat confusing. It was not clear whether or not the models were appropriately applied to evaluate a portion of the BDCP attributes.

The Effects Analysis modeling of salmon sensitivity to water temperature during egg incubation in the Sacramento River is not clear, given that the BDCP has no effect on upstream conditions according to some sections of Chapter 5. The Chapter 5 evaluation needs clarification, including a clear description of how the BDCP might affect flow and temperature in this area.

6. How well does the Effects Analysis link to the adaptive management plan and associated monitoring programs?

While both the need for and operative structure of adaptive management is identified considerably more in the Phase 3 review version of the Effects Analysis, it remains

characterized as a silver bullet but without clear articulation about how key assumptions will be vetted or uncertainties resolved to the point that the BDCP goals and objectives are more assured. The concept of adaptive management is appropriately described and allocated a prominent role in the implementation structure. However, the commonly acknowledged process of adaptive management is easily misunderstood and misapplied, often resulting in a loss of rigor and commitment in application. Because of the extensive uncertainties surrounding the assumptions and predictions of the BDCP, the Panel strongly emphasizes institutionalizing an exceedingly rigorous adaptive management process. This is critical in order to avoid the high risk associated with ecological surprises that will be difficult or impossible to reverse once they have occurred. BDCP must make a commitment to the fundamental process, and specifically the required monitoring and independent science review, not just the concept of adaptive management.

Introduction

This report describes the results of an independent scientific review of the Bay Delta Conservation Plan (BDCP) Effects Analysis. At the request of the BDCP participants, the Delta Science Program convened an Independent Science Review Panel (Panel) to assess the scientific soundness of the BDCP Effects Analysis, guided by a Panel Charge with explicit questions to address.

Background and History

The BDCP Working Draft was initially released November 18, 2010 without a detailed effects analysis. This review has been conducted in three phases and was initiated in October 2011. The Panel's initial (Phase 1) review was conducted on the Draft BDCP Effects Analysis' Conceptual Foundation and Analytical Framework and the Entrainment Appendix as an example of the application of the conceptual understanding, methods and analyses discussed in the Conceptual Foundation and Analytical Framework. In the most recent drafts of the BDCP Effects Analysis, the Foundation and Framework (originally Appendix A) concepts were incorporated into Chapter 5: Effects Analysis. During Phase 2, the Panel reviewed drafts of the BDCP Chapter 5: Effects Analysis and drafts of many of the associated technical appendices. Appendices 5.E: Habitat Restoration and 5.G: Fish Life Cycle Models were not reviewed during the Phase 2 review. The BDCP Chapter 5: Effects Analysis and all of its associated technical appendices were reviewed during the Phase 3 review that is summarized in this report.

BDCP Goals and Role of Effects Analysis

The overall goal of the BDCP is to restore and protect ecosystem health, water supply, and water quality within a stable regulatory framework. Component goals include:

- provide for the conservation and management of Covered Species within the Plan Area;
- preserve, restore and enhance aquatic, riparian and associated terrestrial natural communities and ecosystems that support Covered Species within the Plan Area through conservation partnerships;
- allow for projects to proceed that restore and protect water supply, water quality, and ecosystem health within a stable regulatory framework;
- provide a means to implement Covered Activities in a manner that complies with applicable State and Federal fish and wildlife protection and laws, including California Endangered Species Act and Federal Endangered Species Act, and other environmental laws, including the California Environmental Quality Act and National Environmental Policy Act;
- provide a basis for permits necessary to lawfully take Covered Species;
- provide a comprehensive means to coordinate and standardize mitigation and compensation requirements for Covered Activities within the Planning Area;
- provide a less costly, more efficient project review process which results in greater conservation values than project-by-project, species-by-species review; and,
- provide clear expectations and regulatory assurances regarding Covered Activities occurring within the Planning Area.

The Effects Analysis is a critical component for the BDCP. Its purpose is to provide the best scientific assessment of the likely effects of BDCP actions on the species of concern and ecological processes of the Bay-Delta system. The Effects Analysis will, out of necessity, rely heavily on the application of models to quantify the likely results of the BDCP. These include conceptual, numerical, hydrodynamic, operational, and species models. The BDCP Effects Analysis is being conducted and documented through Chapter 5: Effects Analysis and a series of technical appendices centered on common stressors or groups of similar effects. The draft appendices reviewed in Phase 1 of the Effects Analysis review included the Conceptual Foundation and Analytical Framework Appendix (Foundation and Framework) and the Entrainment Technical Appendix. The Foundation and Framework described the high-level vision, purpose, and regulatory foundation for the Effects Analysis. It also provided an overview of the proposed methods to accomplish the analysis. In the most recent drafts of the BDCP Effects Analysis, the Foundation and Framework (originally Appendix A of the BDCP) concepts have been incorporated into Chapter 5: Effects Analysis.

Panel Members

- Alex Parker, Ph. D., California Maritime Academy, California State University (Panel Chair)
- Charles "Si" Simenstad, M.S., University of Washington (Lead Author)
- T. Luke George, Ph.D., Colorado State University
- Nancy Monsen, Ph.D., Stanford University
- Tom Parker, Ph.D., California State University San Francisco
- Greg Ruggerone, Ph.D., Natural Resources Consultants, Inc.
- John Skalski, Ph.D., University of Washington

The Panel member's biographies are included in Appendix A of this report.

Charge to Panel

The Panel was charged with assessing the scientific soundness of Chapter 5: Effects Analysis and the associated technical appendices, including recommendations for how these might be improved with respect to achieving their stated goals (Appendix B). The charge directed the Panel to address six general questions on Chapter 5: Effects Analysis and review of eight specific topics that had been formulated by the BDCP agencies. In addition, seven other questions were addressed on the approach, analysis and models described in the Chapter 5 technical appendices.

Review Schedule

- October 2011
 - The Panel convened in Sacramento to discuss the Foundation and Framework and Entrainment Technical Appendix and made initial recommendations.
- November 2011
 - Phase 1 Panel report completed November 28, 2011.
- April/ May 2012
 - The Panel reconvened in Sacramento to discuss BDCP Chapter 5: Effects Analysis and the many of the technical appendices. Appendices 5.E:

Habitat Restoration and 5.G: Fish Life Cycle Models were not reviewed at this time.

- June 2012
 - Phase 2 Partial Review Panel report completed.
- December 2013
 - An informational briefing was provided for the Panel. It included an overview of changes to the Effects Analysis and associated technical appendices since the Phase 2 review, including the changes made in response to the Panel's previous comments.
- January 2014
 - The Panel convened in Sacramento to discuss the BDCP Chapter 5: Effects Analysis and technical appendices on January 28-29.
- March 2014
 - Phase 3 report completed.

Organization of Report

We have sought to organize the Panel's review comments and recommendations around the questions framing the Charge to the Panel (Appendix B). Given the extensive volume of review material in Chapter 5 and its associated appendices, our ability to draw on other chapters in the entire BDCP document and all other supplemental material provided to the Panel was considerably limited and inconsistent. However, we attempted to reduce our own uncertainties by exploring the whole body of the BDCP as much as was feasible within the constraints on our time and resources.

For each of the Panel Charge questions we provide a brief **summary** section, a series of bulleted **recommendations**, and a **comments** section with more detailed discussion. In order to maintain this structure throughout the report, there is some redundancy, particularly between the summary comments and detailed comments sections.

Summary observations

Responses to Phase 1 and Phase 2 Panel recommendations

Many of the recommendations from the Phase 2 report should still be referenced while developing the adaptive management plan and initial rules for operating the north Delta diversion facility. Highlighted below are some Phase 2 recommendations that are relevant in this Phase 3 report.

Recommendation 1: Analysis of biological effects needs more consistency and specificity

In some respects, the current draft of the Effects Analyses lacks even more specificity than before, although it may be that sections were moved to other chapters. The 'multi-author' problem is apparent in the variation in assessments found in different locations. Most biological objectives for covered fishes were not fully evaluated in Chapter 5 because information was deemed to be insufficient (Table 5.2.8). Requests for full aquatic food webs were followed and a reasonable conceptual food web was provided, but it was incomplete.

Recommendation 2: Net Effects Analysis needs greater objectivity

Regardless of the degree of uncertainty and the number of linkages without analyses, the conclusion is often overstated as the most beneficial result. Many biological models were analyzed without any sensitivity analyses; consultants would say, 'there's no data,' but they could have said, 'what if we were just 90% correct here, or 60% correct', or 'what if the benefits of restoring wetlands are delayed 10-15 years over our most positive perspective' – but none of those alternative scenarios were considered.

Recommendation 3: Increase consistency of stressor analysis across covered species, and provide more detail.

Chapter 5 identified a ranking approach that addressed: 1) importance of attribute to the population; 2) effect of stressor on individuals; and, 3) certainty of 1 & 2. However, the analysis did not transparently follow through with this approach.

Recommendation 4: Chapter 5 must be a "stand alone" document

The synthesis quality of the Effects Analysis was improved. But reference to specific sections of technical appendices and other supporting documentation could be improved in many sections. Given uncertainty in effects analysis, more description of monitoring and adaptive management would be worthwhile to show that the BDCP would adequately address the uncertainty.

Recommendation 5: Clarify the baseline

The baseline(s) was described, although the baselines vary with regulatory agency. This complicated an already very complicated and lengthy Effects Analysis.

Recommendation 6: Provide systematic understanding and planning for conservation actions, especially restoration

Achieving beneficial conservation measures requires understanding limiting factors, ecosystem processes, sequencing, adaptive management responses, thresholds for certain actions, and interactions and other consequences of these actions. Otherwise, this isn't a conservation plan, but rather a conservation menu that generally fails to describe how major uncertainties will be resolved. For instance, while the Effects Analysis recognizes that suspended sediment has been declining in the Sacramento River and that the new diversions would remove an additional 8-9%, all analyses used a high and constant amount with no mention of downstream sediment effects on either Suisun or San Francisco Bay. Similarly, the uncertainty about being able to remove *Egeria* or other invasive species is not directly addressed in Chapter 5. *Egeria* is certainly poorly considered in the context of the aquatic food webs. Bivalves are not incorporated into aquatic food web analyses, although they're mentioned as 'uncertainties'.

While the conceptual model of food web enhancement support of covered species through restoration of tidal wetlands is more thoroughly covered, potential changes in the contributions of different food web sources and subsidies are still treated as disparate. Discussion of the Delta's potential food web structure and dynamics under BDCP conservation measures still fails to treat the Delta as a system, with spatially and temporally integrated sources of phytoplankton-based and detritus-based secondary

production. There remains the need to provide a synthetic view of the potential benefit of restoration to the covered species that represents the integrated ecosystems and processes that fuel that food web, and potentially enhance it under the BDCP.

No additional detail has been provided for the Restoration Opportunity Areas (ROAs), other than their general locations. There is very little mention of how they will be connected, interact or be sequenced. What criteria have been developed to provide that guidance, or is it entirely dependent on opportunity (real estate costs, availability, public land, etc.)? Ultimately, adaptive management incorporating an extensive management structure and large representation of stakeholders will need to be implemented in order to resolve issues and uncertainties. There is a tremendous trust embodied in an ill-defined adaptive management process.

Recommendation 7: Include indirect effects of contaminants as part of Appendix 5.D: Contaminants

Indirect effects of contaminants on covered species via food web effects (i.e., contaminant effects on the microorganisms that make up the food web that covered species depend on) are almost certainly important.

Recommendation 8: Accurately characterize food resources and food webs

While there is now more comprehensive assessment of both phytoplankton- and detritus-based food web pathways proposed to be enhanced by BDCP conservation measures, the Effects Analysis still leaves the impression that phytoplankton and macrophyte (e.g., tidal marsh) production are separate, almost “opposing” alternative food webs. Only a simple depth model is used for phytoplankton production, nothing else incorporated. Many things are now mentioned in the text, no analyses incorporated, no discussion of potentially modified planktonic composition, etc.

Recommendation 9: The hydrodynamic modeling needs to capture the entire domain of effects

1) New guidelines will need to be put in place to regulate tidal (and maybe tidally averaged reverse flows) in the north Delta channels including Steamboat, Sutter, and Georgiana Sloughs. The operation of the Delta Cross Channel also needs to be rethought. These new guiding regulations need to be in place *before* exports start to occur in the system.

2) The current Effects Analysis does not consider the influence of shifting timing of withdrawals on San Francisco Bay circulation patterns and ecology. This is a significant omission with ecologically important implications.

Recommendation 10: Incorporate life cycle models for all species, as quantitatively as possible

Appendix 5.G identified a number of life cycle models, but eliminated all but two to be used in the effects analysis. The Panel questioned whether some models were inappropriately dismissed. The two models used in Chapter 5 both involved winter Chinook salmon. Thus, the large majority of covered species were not evaluated with life cycle models. The Panel asks why the BDCP did not develop life cycle models when beginning the process.

Recommendation 11: Consider salmonids at stock and life history scale

This aspect of the Effects Analysis was also improved. Each salmonid stock was evaluated. "Forager" versus "migrant" life histories were compared and evaluated, but proportions of each life history type did not seem to be considered in the analysis of net effects. Furthermore, the relative proportion of wild versus hatchery fish contributing to each life history type was not considered.

Recommendation 12: Identify analytical tools that need to be developed to address the extremely high uncertainty involved with calculating sediment supply and turbidity

Multiple statements within Chapter 5 and Appendix 5.C indicate that turbidity distribution is largely unknown.

Recommendation 13: Levels of uncertainty are not adequately addressed

The Effects Analysis provides an improved recognition of uncertainty, but there's not better resolution of uncertainty than in previous drafts and the more complete discussion of uncertainty is often buried in the appendices. As a result, Chapter 5 reflects the lowest common denominator in terms of uncertainty. The level of uncertainty was often mentioned when evaluating the effect of a stressor on a species. Uncertainty was also mentioned when estimating net effects. However, conclusions regarding covered fish often overstated potential beneficial effects while not adequately addressing the lower-end effects.

Recommendation 15: Include sensitivity analyses and model validation in the effects analysis for covered fish species

While sensitivity analyses would have informed the Effects Analysis in the case of some of the biological models, this recommendation was generally not followed.

Recommendation 16: Provide more detail about the specific approaches that will be used when implementing adaptive management

Given the tremendous levels of uncertainty associated with critical assumptions and predictions inherent in the Effects Analysis, the burden of sustaining or enhancing covered species will seemingly fall almost entirely on adaptive management, particularly "active" adaptive management where explicit interventions may be required. However, it remains unclear how many of the critical uncertainties can or will be addressed as explicit experiments. While the Adaptive Management Plan is appropriately, and often effectively, designed to specifically address the major uncertainties, thresholds, triggers and alternative measures need to be explicitly derived from conceptual and numerical models. In some cases, metrics or success criteria have yet to be identified (e.g., Table 3.D.2). Furthermore, the critical monitoring that would be required for effective decision making and adjustments are often relegated to research actions rather than mandated effectiveness monitoring, which presents potential lack of commitment or delay in timely resolution of critical uncertainties. Given the critical importance of monitoring and adaptive management to BDCP success, it would be worthwhile to have an explicit section within Chapter 5 that specifies how monitoring and adaptive management has

been designed and implemented to address specific uncertainties, test critical assumptions and predictions and sequenced to improve the chance of success.

Recommendation 17: Ensure a declining fish population (e.g., longfin smelt) does not decline further while waiting for possible beneficial effects of habitat restoration

The key assumption is that food production will be the primary benefit to longfin smelt from habitat restoration measures. Winter-spring flow is also believed to be key factor affecting abundance. Chapter 5 states that the key question is the extent to which abundance can be increased through improved food production and how these improvements interact with the spring outflow-abundance relationship. Recognition of the length of time needed to restore habitats and increase food production for longfin smelt could be strengthened in Chapter 5.

Accessibility of Effects Analysis elements

The Panel recognizes that the complexities involved in the process to develop and the ultimate structure of the BDCP are enormous, and as a consequence reviewing one component such as the Effects Analysis can be inhibited by lack of clear knowledge of the other components, expanded detail or underlying rationale. Furthermore, the Panel found it difficult to readily track down key information in the 745 page Effects Analysis (Chapter 5), which was supported with eight appendices containing an additional 4,500 pages. In general, in spite of its length, we often found assumptions or conclusions stated in the Effects Analysis to be lacking in sufficient detail to stand alone without links to Effects Analysis appendices or other BDCP chapters that provided the necessary detail or background. Although outside the charge of the Panel, we often found after digging further into the BDCP documents that the Effects Analysis was supported with some information. We recommend that for recognition of the voluminous and detailed information supporting the Effects Analysis, and ease of migrating through it, a simple system of (appendix/chapter and page-line number) cross referencing be employed to point the reader to that supporting information.

General Charge Questions

1. How well does the Effects Analysis meet its expected goals?

Summary

Compared to the initial development of the BDCP Effects Analysis, the Panel consensus is that the Phase 3 version is a much improved and impressive compilation of background material and scientific and technical knowledge about the Bay-Delta that provided a plausible basis for the conservation measures. The Panel concluded that all of the available data and arguments for the rationale behind the Effects Analysis assumptions and conclusions are contained within the BDCP documents, although we suggest that the Effects Analysis (Chapter 5) itself is still poorly substantiated and leaves too much to appendices and other BDCP chapters without explicit cross references. The lack of accessibility to information conveys a “trust us” message.

Evaluation of BDCP effects was typically systematic in that it attempted to identify key attributes affecting Covered Species and described, to the extent possible, the

importance of that attribute, the potential effect of the BDCP on the attribute, and uncertainty regarding the evaluation. Findings from multiple approaches taken to assess potential effects were described and strengths and shortcomings were identified when possible. However, this level of detail, which sometimes included conflicting information, inhibits rather than elucidates comprehension of the findings.

The tenuous conclusion drawn from the Effects Analysis is that many of the critical justifications behind the supposed benefits of the conservation measures are highly uncertain. Other than the impression that the foundation of the BDCP is weak in many respects, the default burden to ensure Covered Species benefit, if not recovery, rests on adaptive management. The adequacy of the BDCP therefore rests not in the intent and development of the conservation measures, but in the rigor and application of adaptive management to ensure that the critical uncertainties are addressed and strategically incorporated into a progressively refined Plan.

There is great potential in the area of decreasing invasive aquatic vegetation (IAV) abundance. Control of extremely invasive IAV, such as *Egeria densa* (Brazilian waterweed) and *Eichhornia crassipes* (water hyacinth), could be substantial and effective if the Plan follows through on its actions. The prospects of success with predator control appear marginal and then only if hotspot actions are followed through year after year. The effects of water withdrawals by the Plan may lead to expanded populations of the non-indigenous, invasive clams *Potamocorbula amurensis* and *Corbicula fluminea* without further direct actions to control their population growth. The fate of *Microcystis aeruginosa* is also not promising. Between trends in climate warming and planned water withdrawals, the prospects for *Microcystis* blooms appear to remain unchanged or slightly worse under the Plan, although the direction of these potential outcomes is highly uncertain.

The Effects Analysis develops a robust conceptual model of aquatic food webs and the diverse linkages that may impact the net production of food for covered fish species. Yet, the Effects Analysis contains a number of assumptions, some of which are inappropriate (such as the magnitude and location of invasive clam depression of phytoplankton production), and others highly uncertain. Uncertainties are mentioned, but no effort was made to include conservation efforts reaching only a portion of the biological objectives and goals. Thus the analysis of effects further assumes only the most beneficial potential results, but doesn't incorporate other possibilities. Other aspects of food webs in aquatic habitats are described but remain unanalyzed, some of which may enhance, while others may inhibit achievement of biological objectives. While the overall conceptual model is adequate, integration and synthesis is lacking. Consequently the conclusions and net effects are not appropriate given the gaps in analyses and the uncertainties.

For terrestrial communities and covered species, the Effects Analysis provides a simple accounting of the number of acres of natural communities and suitable habitat that will be removed and restored but very little information is provided about the management actions that will be implemented to maintain them over the duration of the conservation plan.

Recommendations

- Provide detailed cross-referencing and indexing between Chapter 5 and the associated technical appendices as well as other chapters of the BDCP, especially the Adaptive Management Plan.
- Improve reporting of uncertainty levels within Chapter 5 Effects Analysis, including within the Executive Summary.
- Identify the most relevant monitoring indicators necessary to evaluate the trajectory of outcomes with respect to the biological objectives,
- Complete work on biological objectives.
- Provide triggers for adaptive management
- Guide the scientific community by highlighted research priorities to address critical information gaps.
- Improve on the systematic approach for integrating net effects for Covered Species.
- Develop life cycle models for each of the Covered Species in order to evaluate BDCP effects

Comments

The length and detail of the text and accompanying tables indicate considerable effort to document information used to determine the net effects. However, this level of detail, which sometimes included conflicting information, inhibits rather than elucidates comprehension of the Effects Analysis findings.

Overall, the BDCP and the 22 conservation measures have the goal to enhance fish and wildlife species in the Plan Area. Twenty-one of the conservation measures involve actions intended to restore habitat and benefit Covered Species. Conservation Measure 1 (Water Facilities and Operation) also has the goal to benefit covered species but this specific action involves activities that may adversely impact species (e.g., water removal and construction activities) while also benefiting some species (e.g., reduced entrainment at the south Delta pumps). Therefore, a key goal of the BDCP Effects Analysis is to determine whether the overall positive effects of the conservation measures outweigh the adverse effects of water removal and project construction, and if so, to what degree.

The Effects Analysis attempted to evaluate the effects of the BDCP on each covered fish species in an open, unbiased manner. Sixteen life-cycle models for Covered Species were examined for applicability to the BDCP, but only two were deemed to be relevant. It was not clear why life cycle models were not developed for the specific purpose of evaluating BDCP effects on each of the Covered Species. Quantitative effects could not be described, rather effects of each attribute were ranked as zero, low, moderate, or high effect. A systematic approach to synthesize the overall net effect on each species was not used even though a ranking approach that could have been used in a systematic roll-up was described. Instead, professional judgment was used to assess the overall net effect.

If there is one area of general scientific consensus among the Panel about the implementation of the Bay Delta Conservation Plan is that its outcomes remain highly uncertain. As such, one would expect that the Effects Analysis would reflect this general

conclusion by stressing a high level of uncertainty around all of its conclusions. There is also general consensus among stakeholders that the high level of uncertainty should not be an impediment to any action in the restoration of the Bay Delta ecosystem. The only way to address the highly uncertain outcomes of BDCP implementation is through rigorous monitoring and adaptive management. The BDCP Effects Analysis should better integrate where uncertainty exists, identify the most relevant monitoring indicators necessary to evaluate the trajectory of the outcome, provide triggers for adaptive management and guide the scientific community by highlighted research priorities to address critical information gaps. On these points the Effects Analysis as a stand-alone document falls short.

Table 5.2-8 identifies the biological objectives for each of the covered fish species and whether or not the Effects Analysis was able to assess the likelihood of the BDCP achieving the objectives. Some of the biological objectives were quantitative, thereby providing a specific metric that could be evaluated both prior to BDCP implementation and after implementation. For example, for winter-run Chinook originating in the Sacramento River, the objective is to achieve a 5-yr geometric mean survival through the Delta of 52% by year 19 (from an estimated 40% at present), to 54% by year 28, and to 57% by year 40. Although the table notes that this objective is interim and subject to possible change as new data are collected, the Review Panel complements the BDCP team for developing quantitative biological objectives to be achieved within specific time periods. Ideally, the Effects Analysis should evaluate likelihood of the BDCP achieving each biological objective.

The inability to fully evaluate the likelihood of achieving each biological objective at this time highlights the need for a rigorous monitoring and Adaptive Management Plan. Chapter 5 seems to recognize this need in light of the incomplete evaluation of biological objectives. The Panel was not tasked with reviewing monitoring and adaptive management plans. Nevertheless, monitoring efforts should be designed to quantify whether or not the biological objectives are being achieved. The adaptive management plan needs to be linked to monitoring with identified trigger points and actions to steer the effort towards achievement of the biological objectives.

For terrestrial communities and covered species, the Effects Analysis, for the most part, provides a simple accounting of the number of acres of natural communities and suitable habitat that will be removed and restored but very little information about the management actions that will be implemented to maintain them over the duration of the conservation plan. The estimates of habitat restoration assume that restoration targets for the different habitats will be achieved with certainty, an assumption that unlikely to be met. In addition, the contribution of natural community restoration to species habitat restoration is estimated by multiplying the percentage of modeled habitat comprising the natural community by the total acres of natural community restoration in the plan area. This approach, however, confounds the spatially explicit nature of many of the species distributions within the Plan Area. For instance, only the riparian woodland south of Highway 4 within the Plan Area is considered potential riparian woodrat habitat which makes sense given their current distribution. The riparian woodland in this region currently comprises approximately 12.1% of the riparian woodland in the entire Plan Area. It is inappropriate to apply this percentage the estimate the amount of restored habitat in the Plan Area that will be available to riparian woodrats. If none of the

restored habitat occurs south of Highway 4 then none of it will be potentially available to riparian woodrats. It makes much more sense to identify only riparian woodland restored south of Highway 4 as potential riparian woodrat habitat. Because the distribution of many of the species in the Plan Area is limited by their current distribution and dispersal abilities, the potential for colonization of restored areas should be identified using spatially explicit information. In the case of the riparian brush rabbit and riparian woodrat, a specified number of acres of riparian woodland should be restored within their potential range in the Plan Area.

The issue of the management of terrestrial communities and covered species is addressed in very broad terms in Chapter 5. In some cases there is mention of maintaining communities in a successional state that will make it suitable for a particular species (e.g., early successional riparian forest for riparian brush rabbits and western yellow-billed cuckoo), but many of the uncertainties surrounding long-term management of species and habitats are subsumed into adaptive management. Adaptive management is unlikely to succeed unless clear targets and thresholds for alternative management approaches are identified.

2. How complete is the Effects Analysis; how clearly are the methods described?

Summary

The Effects Analysis is a monumental effort incorporating over 745 pages of text and another 4,500 page of supporting appendices. The assessment covers potential changes in the physical environment, natural communities (12), fish (11 species), wildlife (25) and plant (12) species associated with BDCP. For fish species, 12 different categories of stressors and 32 attributes were examined over four different life stages. As many as 14 different operating scenarios were examined from the status quo to the long-term effects of BDCP implementation with climate change. For terrestrial species, areas of habitat loss and gained through management actions were examined.

Chapter 5 provides an overview of the spatial and temporal scope of the analysis, definitions of project baselines that differ depending on regulatory authority, recognition of climate change information, identification of a variety of models used to evaluate effects, treatment of viable salmon population criteria, and the approach to determining net effects on fish and wildlife. Biological goals and objectives were identified; this is important because the Effects Analysis should address each biological objective.

As might be expected, with the size of the Effects Analysis task, the quality of the assessments ranged in scientific rigor based on the amount of available data and best available science. Some aspects of the assessment, e.g., such as water quality and flow, were quantitatively assessed using sophisticated mathematical models. Aspects of the Chinook salmon assessment were also based on empirical data and process-based models. However, for many of the other fish species and their potential stressors, conceptual models supported by the scientific literature were the only recourse. In the case of Effects Analysis on fish, a workshop of professional biologists was used to incorporate feedback and to better express levels of uncertainty associated with assessment conclusions. The distinction between conclusions drawn from quantitative models and conceptual models was made clear.

The vastness of the Effects Analysis report and appendices is both its strength and weakness. In order to draw conclusions regarding effects of individual stressors or net effects on a species, it was often necessary in the report to draw on information from a number of appendices or other sections of the report. In many cases, these sections were not referenced or the specific findings of those sections not restated. This leaves the reader to hunt for the pertinent facts. It also appears at times that conclusions are based on a select subset of the facts that influence both the strength and certainty of the conclusions.

Because the variety of topics that the BDCP covers, how clearly the methods are described varies between topics. Several panelists gave input into Question 2 based on their areas of expertise.

Covered Fish

Approximately 72% of the objectives for covered fish could not be fully evaluated at this time due to insufficient information. The overall net effects conclusion for each species seemed to be based on the judgment of the authors, rather than a systematic ranking of attribute importance, change in response to the BDCP, and uncertainty in the rankings. Sixteen life cycle models for Covered Species were examined for applicability to the BDCP, but only two were deemed to be relevant, although the Panel is concerned about the exclusion of some life-cycle models. A systematic approach for synthesizing the net effect on each Covered Species was not used even though a ranking system was described that could have been used as a semi-quantitative scoring approach. Instead, professional judgment was used to assess the overall net effect.

In section 5.5, the text describes a numeric ranking for evaluating the importance of the attribute to the species, and the effect of the BDCP action on the attribute. The summary table (e.g., Fig. 5.5.1-5) was extremely difficult to read, used text to describe the effect (zero to high) and color to describe certainty. A small, essentially illegible “-” sign identified negative rankings. This summary table needs to be redesigned to improve readability.

No major omissions for the scientific literature or failure to use best available data were found in the Effects Analysis. However, the Effects Analysis did not develop new methods when gaps in assessment capabilities were encountered. For example, no attempt was made to modify any of the existing delta smelt models for the express purpose of this assessment.

An inevitable risk in using any mathematical model is extrapolation outside the range of the model. This extrapolation is likely whenever projecting to environmental conditions that have not yet occurred such as the changes that could be brought about by the BDCP. It is imperative that model-based assessments clearly state when such extrapolation is occurring and the potential direction of bias that might likely arise.

Hydrodynamics

The coupling of the multi-D, DSM2, and CALSIM II models is not a standard method that would naturally be understood by the reader. The documentation for this coupling is part of the EIS documentation, not part of the BDCP documentation. A short summary of the method should be included in Chapter 5.

Terrestrial species

The methods for the terrestrial species are adequately described in the various appendices (but see specific comments on the description of the methods for the habitat restoration in Appendix 5.J.B).

Recommendations

Over-arching recommendations

- Include a table of cross-references for each section or appendix referenced in the Net Effects.
- Add formal comparisons of model results in the Effects Analysis and appendices.
- Include within the Net Effect sections, discussions of contradictions or non-supportive facts in order to better capture some of the uncertainty in the conclusions.
- Emphasize the following Effects Analysis statement: *“These expectations represent a working hypothesis of the relationship between actions, stressors, and biological performance.”*

Covered fish

- Model-based assessments should clearly state when extrapolation is occurring and the potential direction of bias that might likely arise.
- Redo the format of the effects on attributes summary tables (e.g., Fig. 5.5.1-5) to improve readability.

Hydrodynamics

- A short summary of the method to inter-link multi-D hydrodynamic models, 1-D (DSM2) models, and CALSIM II should be included in Chapter 5.

Comments

Effects on Covered Fish

Chapter 5 addressed topics that it should address given information available at this time. Chapter 5 provides an overview of the:

- spatial and temporal scope of the analysis
- definitions of project baselines that differ depending on regulatory authority
- recognition of climate change effects on future conditions
- identification of BDCP actions
- identification of a variety of models and their limitations for evaluating BDCP effects
- an ESA take assessment including effects on viable salmon population criteria
- a qualitative approach for determining effects of each attribute on species habitat and performance
- an approach for classifying certainty of the effects analysis, and
- a description of the approach for evaluating overall net effects of the BDCP on each fish and wildlife species.

Additionally, biological goals and objectives were identified in Chapter 5. Identification of biological goals and objectives in Chapter 5 is important because the Effects Analysis

should address the ability of the BDCP to achieve each biological objective. However, Chapter 5 states that approximately 72% of the objectives for covered fish could not be fully evaluated at this time due to insufficient information. It is noted in Chapter 5 that these information needs would be incorporated into monitoring and research actions, which are described in Section 3.6 (not reviewed by the Panel). Given the incomplete information, the Effects Analysis states, "*These expectations represent a working hypothesis of the relationship between actions, stressors, and biological performance.*" This is an important statement that should be highlighted in Chapter 5 rather than in the middle of a paragraph on page 5.2-36.

Implementation of methods for evaluating BDCP effects was not readily transparent. Section 5.5 describes a numeric ranking approach for evaluating 1) the importance of the attribute to the species, and 2) the effect of the BDCP action on the attribute. Rankings reportedly ranged from -4 to +4. These two values were reportedly multiplied to develop a ranking of effect for each attribute. Certainty was reportedly evaluated using the same numerical ranking approach for both the importance of the attribute on the species and the BDCP effect on the species attribute. This approach seems reasonable given the limitations of existing information, and the evaluation would be transparent. However, the numeric values of these rankings were not presented or discussed in the BDCP. Instead, figures were presented (e.g., Fig. 5.5.1-5) that used text to describe the effect (zero to high) and color to describe certainty. A small, essentially illegible "-" sign identified negative rankings. It was not clear whether this summary figure incorporated the importance of the attribute to the population, although importance of the attribute was often described in the text.

The numeric ranking approach described above was not used to evaluate net effects of the BDCP on each species, even though it seems that it could have been used and compared with the professional judgment evaluations. Instead, the overall net effects conclusion for each species seemed to be based on the judgment of the authors, rather than a systematic ranking of attribute importance, change in response to the BDCP, and uncertainty in the rankings. Chapter 5 notes that its conclusions were compared with professional judgments of agency personnel provided during a series of workshops in August 2013. This is worthwhile, but a table showing the variability in the judgments would have been useful as a means for indicating variability in the assessment rankings.

The Panel does not provide comments on methodologies presented in the technical appendices, except when discussed below. The level of detail in the descriptions of methodologies in the appendices varies considerably. In many cases, the original document must be consulted for a description of the methodology. Given the variety of information sources, referral to the original report for methodology was not unexpected.

Hydrodynamics

One of the issues that had to be worked through with the hydrodynamic models for the Effects Analysis was how to use hydrodynamic models that were designed for the current bathymetric configuration of the Delta and the watershed. The CALSIM II model is a watershed optimization model that has operational criteria based on salinity intrusion into the Delta. Changing main point of diversion in Conservation Measure 1, adding ROAs in Conservation Measure 3, and factoring in climate change (especially

sea level rise), all change the circulation patterns in the Delta and the associated salinity intrusion. It is necessary to use the physically based multi-dimensional hydrodynamic models to first calculate hydrodynamic parameters (stage and flow) and salinity throughout the system. Because the multi-dimensional models are computationally intensive to run, the results of the multi-dimensional models are used to calibrate the DSM2 (1-D) model. The DSM2 (1-D) model is then used to create the relationship between salinity intrusion and river input flows. This river inflow-salinity intrusion relationship is what CALSIM II needs for optimization.

The coupling of the multi-D, DSM2, and CALSIM II models is not a standard method that would naturally be understood by the reader. The documentation for this coupling is part of the Environmental Impact Statement documentation, not part of the BDCP documentation. A short summary of the method should be included in Chapter 5.

Effects on Terrestrial Species

The methods for the terrestrial species are adequately described in the various appendices (but see specific comments on the description of the methods for the habitat restoration in Appendix 5.J.B).

3. Is the Effects Analysis reasonable and scientifically defensible? How clearly are the net effects results conveyed in the text, figures and tables?

Summary

The effects analysis covers a multitude of topics. Each panelist provided input into Question 3 based on their areas of expertise.

Overall approach to determine net effects

The Effects Analysis, particularly for covered fish, tries to incorporate information on potentially beneficial or detrimental effects covering 12 different stressors, 32 attributes, and multiple life stages using best available information and science. Only a perfect life cycle model with perfect information on all the effects and their interactions could possibly weight the results correctly and draw unambiguous conclusions. Any and all actual effects analyses are far from that measure of perfection, including the BDCP. The effect summary figures (e.g., Figure 5.5.2-5) attempt to illustrate the multidimensional aspects of the assessment process and, along with the Net Effect narratives, try to convey an overall assessment conclusion. A serious limiting factor of the current cumulative Net Effects is a near complete absence of any explicit weighting (in summary tables) of the biological importance of the many attributes under consideration (e.g., Figure 5.5.1-5). Size and direction of anticipated effects on the attributes is provided in the summary figures, along with color coding levels of certainty. Even though summary tables show values for each life stage, what cannot be discerned is whether any critical life stages or attributes are being adversely affected by the BDCP. Consequently, it is also unclear whether the Net Effects conclusions are correctly taking critical life stages into account when deriving overall Net Effects conclusions.

The approach to net effect conclusions needs to be reconsidered and revamped. The net effect summary figure (e.g., Figure 5.5.2-5) does not include the relative importance of the categories (e.g., food, entrainment, etc.). Without incorporating their relative importance in the summary figure, net effect conclusions are potentially meaningless

and uncertainty cannot be characterized. The net effect conclusions for a fish species need to therefore take into account the relative importance of the various categories, make them explicit, and interpret Plan effects within that context on a species-by-species basis.

Covered Fish

The Effects Analysis does not adequately defend conclusions regarding the net effects of the BDCP, including habitat restoration. Habitat restoration certainly has the potential to increase the productivity of species such as salmonids, but the literature contains relatively few studies documenting the population response of salmonids to habitat restoration. The conclusion statements from Chapter 5 (and/or the Executive Summary) tend to overstate the beneficial effects of BDCP for many different fish populations (e.g., salmonids, delta smelt, green and white sturgeon). The net effects analysis tends to over-reach conclusions of positive benefits for covered fish species, given the inability to quantify the overall net effect and the realization of high uncertainty.

Key issues/questions that still need to be address for covered fish include:

1. The importance of interactions between BDCP flows and habitat restoration.
2. Will the migrant life history sufficiently benefit from conservation measures to offset moderate negative impacts related to reduced spring flows? Migrant salmonids may benefit less from conservation measures, and may experience a negative net effect.
3. To what extent is foraging habitat and exposure of foraging salmonids to predators affected by reduced spring flows?
4. The text does not distinguish between hatchery versus wild salmonids in the analysis.

Conceptual Models

In general, the conceptual models for dissolved oxygen and contaminants are well developed, although consideration of nutrient form and nutrient ratios (e.g., Glibert *et al.* 2011) would be a nice addition given the interest and recent publications on these topics. Also, algal toxins could be an attribute for monitoring to reduce uncertainty in contaminants and food web conceptual models.

Although there are good synthetic conceptual models developed for the Bay-Delta longfin smelt population encapsulated in the Effects Analysis (e.g., Baxter 2010; Rosenfield 2010), the conceptual model is still constrained by the lack of a life-history model that would elucidate the role of prey composition and abundance in population dynamics.

Food Webs

Restoration of tidal wetlands (and other communities) is highly uncertain and at least an extremely long process. The Effects Analysis does not adequately justify the critical assumption of the benefit of tidal wetland restoration as a food web subsidy for covered pelagic fish given the uncertainties of tidal wetland restoration itself. The conceptual model of the food web appears to include many of these processes. However, within the narrative current understanding as well as the implications of inherent uncertainties are not fully explored.

Organic matter subsidies to the Delta Food Web

There is an expectation that restoration activities will result in increases in abundance of lower trophic levels but the structure of the lower food web will be critical in whether this increased production can support covered species. Not only quantity, but also quality of the primary production that is supported by restoration activities is important. Water residence time within ROAs and other characteristic transport timescales for Delta channels are not the only factors to consider. The type of phytoplankton primary production that is stimulated is highly uncertain and likely dependent upon water temperature, nutrient concentrations, vertical mixing and grazing. In addition, an increased residence time may promote toxigenic cyanobacteria (*Microcystis aeruginosa*).

Hydrodynamics and physical changes at export facilities

For hydrodynamic modeling, only one set of ROAs were modeled. Because the locations of these assumed ROAs are not being presented to the public, there are details of the hydrodynamic modeling that cannot be factored into the Panel's evaluation of the Effects Analysis.

Conservation Measure 1 now includes significant modifications to Clifton Court Forebay. This region has been identified as a predation hot spot by multiple studies. Reduction in predation hot spots should be considered in the physical design.

Terrestrial species

The Effects Analysis for terrestrial species focuses almost exclusively on a simple summation of the number of acres of suitable habitat that are removed or restored for each species by the conservation measures. The simple accounting approach does not consider landscape-level effects such as connectivity and patch size nor does it take into account differences in habitat quality.

Recommendations

Overall approach to determine net effects

- Clearly indicate on effect summary figures (e.g., Figure 5.5.2-5) both beneficial (+) and detrimental (–) effects.
- In order to incorporate biological importance into the Net Effects process, the rows (i.e., categories, attributes) of the effects figures (e.g., Figure 5.5.21-5) could be ranked or rearranged in clusters according to biological importance for the specific species (e.g., high, medium, low). In this way, it would be easier to assess whether any biologically important attributes are likely to be negatively impacted and at what level of impact. It will also allow readers to discern whether any biologically important attributes also have high levels of uncertainty assigned to them.
- From the August 2013 Covered Fish workshops, it would be valuable to include in the Net Effects summary, what fraction of the attendees agreed with the Net Effects conclusions (i.e., direction, amplitude and level of certainty).

Covered fish

- Examine and re-write conclusion statements about population net effects in both Chapter 5 and the Executive Summary to objectively express the range in anticipated population effects.
- Evaluate effects of conservation measure attributes on species while considering all other potentially interacting conservation measures.
- Consider relative abundance of salmon life histories when evaluating net effects on each species.
- “Wild” salmonids should be considered separately from hatchery fish whenever possible.

Conceptual Models

- Consideration of nutrient form and nutrient ratios (e.g., Dugdale *et al.* 2007; Glibert *et al.* 2011) would be a nice addition to food web models given the interest and recent publications on these topics.
- Algal toxins could be an attribute for monitoring to reduce uncertainty in contaminants and food web conceptual models.

Food Web

- A simple surface area versus water volume calculation would provide a first-order estimate of potential food subsidy to open water habitats of the low salinity zone.
- Evaluate and compare the magnitude and temporal and spatial variation in the multiple organic matter subsidies to the Delta food web.
- Incorporate into the Effects Analysis the idea that tidal wetland restoration may mitigate some of the nutrient loading into Delta by acting as a nutrient sink through emergent vegetation production, phytoplankton production as well as fluxes to the atmosphere via denitrification.
- Estimate the potential food web subsidy attained based on the degree to which habitats are connected hydraulically to Suisun and Grizzly Bays. These areas could serve as “proof of concept” for other, unidentified Restoration Opportunity Areas.

Hydrodynamics and physical changes at export facilities

- When Conservation Measure 3 is implemented, the details of the connection between the Restoration Opportunity Areas and the adjacent channels and the order in which the Restoration Opportunity Areas are established need to be top design criteria.
- Since Conservation Measure 1 is proposing significant physical changes be made to Clifton Court Forebay, the identified predation hot spots within Clifton Court Forebay should be considered in the re-design.

Terrestrial species

- Landscape-level effects should be considered.

Comments

Effects on Covered Fishes

A Comprehensive Summary Figure Would Be Useful. For specific actions affecting covered fishes, the Effects Analysis summarizes findings of multiples investigations when available and often qualifies the findings with opinion statements of how important the attribute might be and how certain the finding is. This assessment by the authors of the Effects Analysis is often compared with a summary of conclusions, including a statement of uncertainty, developed from a workshop with agency personnel in August 2013. This approach is reasonable given the information available, but as noted elsewhere, improvements could be made to systematically summarize 1) the relative importance of the attribute, 2) the level of change caused by BDCP implementation, and 3) the certainty of this evaluation. The relative importance of an attribute was often provided within the narrative of Chapter 5, but a comprehensive table or figure summarizing this metric was not presented along with the effect of the BDCP on the attribute and the certainty associated with the rankings. A comprehensive summary figure is a key step leading to the overall net effect determination for each species. This figure would also enhance transparency in the final professional judgment of net effects. Furthermore, some sections of the Effects Analysis did not seem to reach a conclusion or describe the certainty about the findings, e.g., text description of Feather River flow effects on spring Chinook (see Feather River discussion below).

Salmonid Life History Increases Uncertainty. Salmonids have a variety of juvenile life history types that result in differential use of Delta habitats over time. The Effects Analysis characterized these life history types as foragers and migrants. Foraging juvenile salmonids are younger, smaller and typically inhabit shallower habitats compared with larger, older yearling salmonids that pass through the Delta relatively quickly. Recognition and consideration of these two life history strategies in the BDCP Effects Analysis (e.g., Fig. 5.5.3-4) is important. However, as noted below, the complex life history of salmonids, including life history differences between wild and hatchery origin fish, leads to greater uncertainty in the overall net effect of the BDCP actions on salmonid populations.

Literature Shows Major Restoration Needed to Improve Fish Populations. The Effects Analysis does not adequately defend conclusions regarding the net effects of the BDCP, such as habitat restoration, on fish species. Habitat restoration certainly has the potential to increase the productivity of species such as salmonids, but the literature, including published papers and technical reports, contains relatively few studies documenting the population response of salmonids to habitat restoration (see reviews by Roni *et al.* 2008, 2011). Findings in the literature on the response of salmonid populations to habitat restoration was not adequately addressed in the Effects Analysis when describing the net effect of each species, although the methods section (5.2.7.10.3) did provide a reference by NMFS stating that quantitative linkages between specific habitat actions and viable salmonid population criteria is difficult. The difficulty in documenting population responses to habitat restoration should be recognized and addressed with large and strategic habitat restoration projects and detailed monitoring. For example, in a comprehensive evaluation of salmon responses to habitat restoration in Puget Sound, Roni *et al.* (2011) concluded:

"Given the large variability in fish response (changes in density or abundance) to restoration, 100% of the habitat would need to be restored to be 95% certain of achieving a 25% increase in smolt production for either species. Our study demonstrates that considerable restoration is needed to produce measurable changes in fish abundance at a watershed scale."

Conclusions Often Overstate Beneficial Effects. The Panel believes that the net effects analysis tends to over-reach conclusions of positive benefits for covered fish species, given the uncertainty and inability to quantify the overall net effect. Given the findings of Roni *et al.* (2011), it may be inappropriate to extend an uncertain but potentially positive effect conclusion to statements about species conservation, especially under future climate scenarios. For example, the following grand conclusion statements from Chapter 5 (and/or the Executive Summary) tend to overstate the beneficial effects of BDCP:

"The magnitude of benefits for winter-run Chinook salmon at the population level cannot be quantified with certainty. Nonetheless, the overall net effect is expected to be a positive change that has the potential to increase the resiliency and abundance of winter-run Chinook salmon relative to existing conditions."

Statements about increased resiliency and abundance are inappropriate given the high uncertainty expressed in the initial sentence. The statements tend to focus on the upper end of beneficial effects rather than a balanced analysis that might capture the range in net effects. The Panel underlined the questionable text.

"The BDCP should help conserve the species in the Plan Area and help it cope with expected climate change...." The term "conserve" implies a large beneficial population effect for salmon that may help the population recover from ESA listing. Maybe the BDCP will lead to a positive effect, but the magnitude of the effect is uncertain, as stated above, so it seems inappropriate to imply the BDCP would eliminate attributes in the Delta that cause lower population viability. The life cycle models suggested climate change effects would overwhelm the evaluated BDCP actions on winter Chinook salmon.

The following conclusion for delta smelt overstates and over-emphasizes the potential for significant beneficial effects (by emphasizing great potential) while also noting the conflicting conclusion of high uncertainty in the net effect: "While there is great potential for large benefits for delta smelt, there is a high level of uncertainty regarding the resulting effects. However, combined with the Fall X2 decision tree, the BDCP will have at least a minor beneficial effect on the species, but a great potential for larger benefits depending on actual food production and location of delta smelt population in relation to restored areas." The high-end benefit is emphasized in the BDCP text. Perhaps there is higher certainty for a positive versus negative net effect but there is high uncertainty for the net effect of actions on the delta smelt population, ranging from little to high population effect. This evaluation would benefit by the removal of "great".

For green and white sturgeon, the BDCP concluded: "Therefore, the BDCP is expected to conserve both species in the Plan Area through improvements in abundance, productivity, life history diversity, and spatial diversity." The term "conserve" implies a large beneficial population effect that was not supported by the evaluation. The conclusion statement also implies and therefore overstates measureable positive

changes to four population viability criteria. These benefits may reflect the goals of the BDCP, but the uncertain magnitude of benefits to sturgeon should not be described as improving abundance, productivity, life history diversity, and spatial diversity.

Interactions between conservation measures. Interactions between BDCP flows and habitat was not adequately addressed in the report. For example, Table 5.5.3-4 shows that habitat units typically increased for foraging salmonids in response to habitat restoration, but the habitat analysis did not appear to consider whether salmonids would have access to the habitat during reduced flows under the BDCP scenarios (see Table 5.E.4-1). For example, flows were expected to be ~15% to 20% lower during January to April when many foraging salmonids are rearing in the Delta area. In other words, how much rearing habitat is available and what is the habitat quality for foraging salmonids when flows have been reduced 10-20%? The Cache Slough region is one example where key habitat restoration sites might be affected by reduced river flows. Perhaps tidal fluctuations overwhelm river flows in some of the lower habitats, but this should be stated in the report. For foraging salmonids, do reduced flows of the BDCP negate the reported habitat gains from some restoration activities? Recommendation: evaluate effects of conservation measure attributes on species while considering all other potentially interacting conservation measures. This approach was taken for some measures (e.g., Delta Passage Model evaluations) but not all.

Migrant salmonids may benefit less from conservation measures and may experience a negative net effect. The effect of each attribute on migrant versus forager salmonids was examined in Chapter 5, but summary Figure 5.5.3-2 did not capture differences in the assumed relative abundances of these life histories among the species. Plan area flows were typically ranked as a moderate negative effect on migrant salmonids in the Sacramento River and a low negative effect on foragers. However, this attribute was ranked the same for each salmonid species regardless of the proportion migrants versus foragers assumed in the population. The negative impact of reduced plan area flows should have been greater on Sacramento River species such as spring Chinook and steelhead that are dominated by migrant life histories.

Migrant life histories are less likely to benefit from habitat restoration activities, which are a key focus of the BDCP conservation measures. This implies that spring Chinook and steelhead may experience less benefit from BDCP actions than other salmonid species, or they may even experience a negative net effect in response to reduced spring flows. The key question, which deserves more attention in the BDCP, is whether the migrant life history will sufficiently benefit from conservation measures to offset moderate negative impacts related to reduced spring flows. This question is key for spring Chinook and steelhead that are composed mostly of migrant life histories.

Characterize uncertainty in plan area flow effects on salmonid life history types. The Delta Passage Model (DPM) is a key tool for this evaluation because it predicts survival of migrant salmonids while considering river flows, passage into interior areas, entrainment to pumps, and passage into the Yolo Bypass. The survival model is largely based on Chinook salmon exceeding 140 mm in fork length, therefore the DPM does not represent foragers or smaller migrants, which are the target of the habitat restoration activities.

The Effects Analysis states that it was assumed with moderate certainty that flow has high importance to foraging winter Chinook salmon, then notes that the moderate level of uncertainty reflects the relative lack of investigation on the influence of flows on smaller salmonids (Page 5.5.3-24, line 39-41). Moderate uncertainty is quite different from moderate certainty, which is also concluded in each salmonid summary figure (e.g., 5.5.3-4). If there is no information on how flows affect survival of smaller foraging salmonids in the Delta, it is difficult to accept a moderate level of certainty associated with the low negative impact of flows on foraging juveniles salmonids, especially when data suggest flow has a significant effect on larger salmonid (migrant) survival (Fig. 5C.5.3-4). To what extent is foraging habitat and exposure of foragers to predators affected by reduced spring flows? For winter Chinook and fall Chinook, the forager life history is the dominant type, indicating less certainty about the net effect of BDCP flows on these species compared with species dominated by migrant life histories that have been tagged and analyzed, e.g., Fig. 5C.5.3-4.

Hatchery versus "wild" origin salmonids. The presence of hatchery salmonids is typically noted in the introductory descriptions of each salmonid species in Chapter 5. The degree to which hatchery salmonids contribute to the two life history types was not described, though hatchery fish are released as migrants. For example, 80% of juvenile spring Chinook were assumed to be migrants. To what extent was this due to the release of migrants from hatcheries given that some of the natural population produces primarily foragers? The text does not otherwise distinguish between hatchery versus wild salmonids in the analysis. Although some hatchery stocks are protected by the ESA, it would seem that wild salmonids would have a higher priority than hatchery-produced salmonids, even though hatchery runs provide important role in the Central Valley and ocean fisheries. Perhaps resolution of effects and uncertainty inhibit analyses specific to wild salmonids. Nevertheless, wild salmonids should be considered independently from hatchery salmonids when possible.

Do habitat actions only affect salmonid capacity and not productivity? Fig. 5.5.3-2 shows BDCP effects on productivity of each salmonid species by attribute. No effect is shown for habitat attributes such as channel margin, floodplain, riparian, etc. In contrast, these attributes are scored in other Figures for each species, e.g., Fig. 5.5.3-4. Does this reflect an opinion that these habitat actions only increase the capacity of the habitat to support salmonids rather than habitat quality?

Obtain more information from life cycle models. Life cycle simulations were only performed for winter-run Chinook salmon using the OBAN and IOS models. Comparison of through-delta survival and adult returns by management scenario (Table 5.G-2) was very useful. One way to compare and evaluate the two models is to assess consistency in the management scenario rank (best to worst) for the various response variables. For instance, if the same management scenario always ranks first, then that would indicate high level of consistency and support for that conclusion. On the other hand, if management scenario rankings varied greatly between assessments then conclusions would have high degrees of uncertainty (See Table 1, below).

Some life cycle models inappropriately excluded. Appendix 5G excluded delta smelt life cycle models in the Effects Analysis without adequate justification. Based on the premise of using the "best available science," it is unclear how none of the delta smelt models could have reached that level of acceptance. One justification was that none of

the models used zooplankton data; however, the BDCP Net Effects assessment indicated zooplankton was only of moderate importance to delta smelts (Figure 5.5.1-5). It would therefore seem that some assumptions about zooplankton could have been made, allowing life-cycle modeling to be performed. Robustness studies could have accompanied the modeling process. Furthermore, if the BDCP team felt none of the delta smelt models to be adequate, why was there no investment made in model development for such an important species of interest?

Net Effects

The Net Effects summary figures (e.g., Figures 5.5.1-5, 5.5.2-5, etc.) are very useful for synopses for each fish species, but they are incomplete. It would be visually helpful to explicitly include both positive (+) and negative (–) signs for each combination of life stage and category. There continue to be discrepancies between conclusions regarding certainty and level of effect between the text and summary tables. The quantitative scoring method described on page 5.5.1 seems to be largely ignored. Instead, a qualitative ocular assessment of the summary tables seems to be applied separately to the certainty and level of effect dimensions. For salmonid species, weighting is discussed for migrant vs. foraging forms, but this too is seemingly ignored (or at least not mentioned) in the Net Effect conclusions.

The approach to Net Effects conclusions needs to be reconsidered and revamped. The Net Effects summary figures (e.g., Figure 5.5.2-5) do not include the relative importance of the categories (e.g., food, entrainment, etc.). Without incorporating their relative importance, Net Effects conclusions are potentially meaningless and uncertainty cannot be characterized. Levels of uncertainty have different weight depending on the importance of the various categories. An assessment might have high uncertainty for all low importance categories and still have high overall certainty if all the important categories carry with them high certainty. Conversely, the overall assessment would have low certainty, if one or more of the high importance categories carry high uncertainty. The Net Effects conclusions for a fish species needs to therefore take into account the relative importance of the various categories, make them explicit, and interpret Plan effects within that context on a species-by-species basis. Uncertainty plus uncertainty is more uncertainty. Uncertainty never averages or cancels out uncertainty; any more than noise plus noise is less noise. One graphical approach to conveying importance of the various categories and attributes is to order or group the rows of the figures according to their importance for a particular fish species. It would then be possible to see if any detrimental effects of the BDCP are associated with any important biological processes or not.

Life-cycle simulations were only performed for winter-run Chinook salmon (i.e., models OBAN and IOS). Comparison of through-Delta survival and adult returns by management scenario (Table 5.G-2) was very useful. One way to characterize model consistency is to assess how consistent the management scenarios rank (best to worst) across the models and different response variables. For instance, if the same management scenario always ranks first, then that would indicate a high level of consistency and support for that conclusion. On the other hand, if management scenario rankings varied greatly between assessments, conclusions would have a high degree of uncertainty.

Restoration of tidal wetlands (and other communities) is highly uncertain or at least an extremely long process

Restoration of tidal wetlands is considered in detail in the section on aquatic food webs (Question 12). In general, tidal wetland restoration of biological function is quite difficult with respect to ecosystem processes beyond tidal flux and especially with respect to ecological equivalency to comparable natural wetlands. This has been reviewed in a number of studies and conclusions have remained consistent over the past two or three decades (e.g., Kentula 1996, Simenstad and Thom 1996, Zedler and Callaway 1999, BenDoer *et al.* 2009, Moilanen *et al.* 2009).

Lack of specificity in Restoration Opportunity Areas limits conclusions of many aspects of Effects Analysis

For the hydrodynamic modeling, only one set of Restoration Opportunity Areas were modeled. (See discussion of implementation of models in Question 2.) Because the locations of these Restoration Opportunity Areas are not being presented to the public, there are details of the modeling that cannot be factored into the Panels evaluation of the Effects Analysis. As examples: 1) in Panel Question 7, the placement of the Restoration Opportunity Areas influences reverse flows in Georgiana Slough, 2) the calibration of the 1-D model based on the 2-D model results is sensitive to Delta Cross Channel operations, which could be the result of Restoration Opportunity Areas representation in the system. (See question 5 Restoration Opportunity Areas modeling discussion.) When Conservation Measure 3 is implemented, the details of the connection between the Restoration Opportunity Areas and the adjacent channels and the order in which the Restoration Opportunity Areas are established need to be top design criteria.

Clifton Court Forebay physical changes need more evaluation before implementation because of its reputation as a predation hotspot

Conservation Measure 1 now includes significant modifications to Clifton Court Forebay. These modifications include building a wall in Clifton Court Forebay to create two separate regions, the north region would receive water from the North Delta pump facilities and the south region would receive water from the existing south Delta channels. In addition, the current size of the Clifton Court Forebay would also be enlarged by flooding an adjacent tract of land to the south. Based on the public panel discussion with ICF and the Fish agencies on January 29, 2014, the philosophy behind the modifications is that the water coming from the North Delta facilities will have already been pre-screened for critical fish species. Therefore, there would be significant savings in not filtering north Delta diversion (NDD) water through the south Delta fish screening facility.

ICF acknowledged that this is a newer element of the design for Conservation Measure 1. There was no documentation in Appendix 5.H (Aquatic Construction and Maintenance Effects) regarding this construction. The building of a dam in the center of Clifton Court Forebay and dredging another tract should be considered in Appendix 5.H. Clifton Court Forebay has been identified as a predation hot spot by multiple studies. The Fish Predation science panel (Grossman *et al.* 2013) stated in their final report that: "Clifton court Forebay (CCFB) has been identified by multiple sources as an inhospitable location for salmonids. Within CCFB several areas are particularly

hazardous including: 1) the deep scour hole just inside CCFB by the radial gates; 2) the trash gates in front of the Tracy Fish Collection Facility; and 3) section of Old River adjacent to the radial gates." Since Conservation Measure 1 is proposing significant physical changes be made to Clifton Court Forebay, these predation hot spots should be considered in the re-design.

Delta Food Web

5.3.38 Cache Slough and Suisun Marsh Restoration Opportunity Areas are suggested as areas of substantial increase in Prod-Acres. Given that these Restoration Opportunity Areas are defined, some work could be done to estimate the potential food web subsidy attained based on the degree to which habitats are connected hydraulically to Suisun and Grizzly Bays. These areas could serve as "proof of concept" for other, unidentified Restoration Opportunity Areas. An interesting outcome of such an exercise would be a determination of the potential for export and trophic transfer (a positive outcome) versus localized cultural eutrophication, increased biochemical oxygen demand and dissolved oxygen sags in tidal sloughs (negative outcome).

The discussion of water residence time throughout the Delta (Section 5.3.36) suggests an increase of 3 to 4 days as compared to the current configuration. But this analysis is also site-specific. The approach used to calculate residence time is also of concern. The residence time in each Restoration Opportunity Areas is a function of bathymetry, the exchange between the Restoration Opportunity Area and the adjacent channels. The 1-D DSM2 model does not have the capability to calculate this parameter. In addition, because the specific locations and configurations of the Restoration Opportunity Areas are not presented in the Effects Analysis, the panel has no basis to comment on the validity of the approach.

The phytoplankton productivity model that results in Prod-Acres is limited in terms of prediction or certainty in outcomes. Again, it comes down to a question not only of quantity but also quality of the primary production that is supported. The result of longer residence time is likely to increase phytoplankton primary production (i.e., "slower is greener") this may not hold when invasive clams are introduced to the system (Lucas and Thompson, 2012). Additionally, the type of phytoplankton primary production that is stimulated is highly uncertain and likely dependent upon water temperature, nutrient concentrations, vertical mixing and grazing. Lehman *et al.* (2013) suggested that increased residence and warmer water temperatures in excess of 19 - 20° C will promote toxigenic cyanobacteria including *Microcystis aeruginosa*. It should be recognized that *Microcystis* is only one potentially important toxigenic cyanobacteria in the Bay-Delta – *Aphanizomenon* was abundant in 2011 and 2012 in the Bay-Delta (Karobe *et al.* 2013).

Tidal wetland restoration may mitigate some of the nutrient loading into the Delta by acting as a nutrient sink through emergent vegetation production, phytoplankton production as well as fluxes to the atmosphere via denitrification. These ideas are not considered within the Effects Analysis. The decay of large amounts of invasive aquatic vegetation (a result of control measures) also has the potential to increase biochemical oxygen demand and inorganic and organic nutrient supply; this may shift phytoplankton community composition and promote local eutrophication. This issue is raised in a single bullet point on page 5.F-130, line 26

Terrestrial Species

Rather than using current estimates of habitat occupancy within the Plan Area to estimate occupancy of restored habitat, we recommend using spatially explicit occupancy models (see comments under question 4). In addition, the minimum width and maximum distance of riparian habitat corridors should be identified for terrestrial mammals that are restricted to riparian habitats (riparian woodrat and riparian brush rabbit). Persistence of these species in the Plan Area requires riparian habitat patches that are sufficiently large to support stable populations as well as riparian corridors that will allow movement between suitable habitat patches. Both the minimum patch size and minimum corridor parameters (width, distance, overstory cover) should be specified to ensure long-term occupancy of restored riparian habitat.

4. How well is uncertainty addressed? How could communication of uncertainty be improved?

Summary

A broad consensus exists among the Panel that Chapter 5 does not adequately address uncertainty. In its current form, at the level of detail conveyed, in the models used, and in the verbal assessments and conclusions, the level of uncertainty is downplayed. Within appendices sometimes more explicit discussion of uncertainties can be found, but a disconnect exists between the summary pages with the conclusions drawn in Chapter 5. In situations in which an array of outcomes may be possible, only the more beneficial outcomes are quantitatively assessed or used in conclusions about the BDCP. Communication of uncertainty would be improved by consideration of a range of potential outcome values in models.

The Panel cannot determine whether the conclusions about covered fish species or other species in the BDCP are accurate. Detailed monitoring is needed to evaluate the BDCP conclusions, in addition to the outcomes for the biological objectives that could not be fully evaluated at this time in the BDCP. The BDCP effects analyses are qualitative and conclusions regarding net effects on each species typically reflect professional opinion. Therefore, the Effects Analysis does not lend itself to evaluation of chained statistical uncertainties. The tremendous length of the documents did not reduce the uncertainty in the overall net effects.

Recommendations

- Unknowns and research needs should be incorporated into the BDCP as explicit conservation measures, in other words, as a required part of the BDCP.
- Monitoring needs, timing and intensity also need more explicit incorporation into the BDCP. While often well explicated in an appendix (e.g., within Appendix 5.F-Biological stressors on covered fish), they are frequently absent within the material discussed in Chapter 5 or treated as an uncertainty.
- Research needs are often mentioned as sections within appendices. These should be consolidated within Chapter 5. This would help guide future research priorities for the Delta.

Comments

Effects on Covered Fishes

For covered fishes, when evaluating the importance of an attribute to a species and evaluating the effect of the BDCP on that attribute, the Effects Analysis was typically careful to describe the level of certainty associated with this evaluation. The evaluation of certainty was typically a judgment by the BDCP authors rather than a quantitative measure of certainty (e.g., standard deviation), therefore estimates of certainty have their own level of uncertainty. The Effects Analysis did not lend itself to evaluation of “chained statistical uncertainties” as identified in the charge questions addressed to the Panel because the effects analyses were not quantitative. Nevertheless, the judgments of certainty have value, though they could be improved upon (see below).

Judgments of certainty were also compared with judgments provided by California agency scientists at the August 2013 workshops. However, identification of agency certainty seemed to be the interpretation by the BDCP authors of the agency response rather than a systematic evaluation of certainty scores. At the January 2014 Effects Analysis Panel meeting, ICF noted that they did not think it was possible to consistently document variability in Effects Analysis evaluations by agency personnel at the August 2013 workshops. As a result, evaluation of certainty of BDCP effects on attributes of each species is limited to the interpretation of the BDCP authors.

Please see discussion above on the overall net Effects Analysis for each species. Although conclusion statements typically stated high uncertainty in the overall net effects, they also tend to ignore uncertainty when highlighting the potential benefits to conservation without also stating the lower end of the effects range.

Monitoring and Research

As an example of the high uncertainty in the BDCP to achieve biological goals and objectives, many of the sections of appendices have sections on monitoring and research needs. These often highlight impacts of conservation measures in which the outcomes may have a range of positive to negative impacts. The unknowns and research needs should be better incorporated into the analyses of biological impacts of the BDCP. At a minimum they should be required as an explicit conservation measure. In a number of instances, especially in Appendices, for example Appendix 5.F, needs are highlighted for a robust monitoring and evaluation program, coupled with a detailed, prescriptive adaptive management plan. BDCP success will depend on monitoring and evaluations and responding to issues as they emerge. Furthermore, high uncertainty in the outcomes for the covered species means that budgets for monitoring and adaptive management must be developed with uncertainty in mind.

Disconnect between uncertainty and BDCP conclusions

Frequently, explicit modeling is reduced to small portions of conceptual models. When a range of potential outcomes may result from uncertainties in multiple conditions, only the most beneficial outcome is considered when coming up with a conclusion or summary. Some of these are discussed in other sections of this report. One example can be found in Appendix 5.F. When considering the impacts of some of the conservation measures, for example, Conservation Measure 13, removal of *Egeria* is discussed with multiple potential effects (Appendix 5.F, p. 5.F-48 and following), some

beneficial, such as removing habitat for predators of covered fish, while others may exacerbate populations problems for covered fish, such as cascading effects through the food chain of the loss of some invertebrates that feed on *Egeria*, shifts in aquatic web linkages, and the rapid replacement of *Egeria* by other invasive submerged aquatic vegetation. Nonetheless, these uncertainties are simply ignored when it comes to conclusions, where it is determined that only the beneficial results of control invasive aquatic vegetation will result from the BDCP (pp. 5.F-48-49). To be fair, occasionally the poorer results dominate conclusions; for example, *Microcystis* may increase due to management activities inside and outside the region but these conclusions fail to emerge in the discussion of the aquatic food webs within Chapter 5.

The discussion of the aquatic food webs is based on a good conceptual model, but the dynamics of the food web are ignored and only a single component, phytoplankton productivity, is modeled as a result of restoration efforts in the relatively near- and far-term. Detrital contributions could also enhance food webs, but are not considered in any detail. Phytoplankton productivity is unrealistically modeled, and assumed to essentially be consumed along linkages that connect directly to covered fish. Chapter 5 does mention invasive bivalves, but fails to incorporate their potential as direct competitors for plankton within the food web, even though that potential is discussed. In other words, the BDCP is inconsistent in how models and analyses handle uncertainty and model assumptions, making it difficult to complete assessment.

Restoration

Because this is discussed in other sections, we will only mention that there is great uncertainty associated with the restoration of the wide range of ecosystems slated for restoration. Many of these systems have a poor record of achieving restoration, especially in short-to-moderate time periods. This range of ecosystems also varies considerably in the degree of difficulty of restoring functions. Nonetheless, the outcomes for conservation measures and their interaction and effectiveness are glossed over and uncertainties are not apparent in conclusions and summary discussions. For example, wetland restoration will require considerable input of sediment in the short-term to meet the outcomes described in the BDCP. Yet Chapter 5 models tidal wetland restoration with a constant concentration of suspended sediment, even though the document discusses the fact that sediment has been declining over the past decades, and further that the operations of the north Delta pumps may remove 8-9% more. In other words, there is considerable inconsistency between a discussion of uncertainty and how uncertainty is incorporated into the conclusions.

Similarly, restoration of many of the terrestrial habitats for other covered species also involves considerable uncertainty, especially as to the rate at which function will return that will be recognized by covered species. Consequently uncertainty of the occupancy targets for terrestrial species are not addressed. In all cases, a single value of number of acres that will be occupied is provided. No estimates of the uncertainty of achieving stated restoration goals nor uncertainty of the proportion of the restored habitat that will be occupied are included.

North Delta Diversion

In addition, the validity of the primary assumption that there will be no entrainment of fish at the north Delta diversion (NDD) should be evaluated. In reality, there will be

some fish lost at the transfer point; therefore, the empirical relationship would be altered including this additional transfer point.

Water Clarity and Suspended Sediments

Section 5.3-24 (lines 31-38) correctly identifies a low level of certainty around changes in water clarity but does not include the potential positive or negative implications for changes in water clarity.

Suspended sediment is one of two key components driving the development of tidal wetlands in the Delta, especially under sea level projections, yet Delta inflow has been experiencing a decline in suspended sediment and operations of the NDD may remove 8-9% more. BDCP indicates there may not be sufficient sediment for marsh restoration (Chap. 5, p. 109).

The NDD operations should factor in suspended sediment into the operational criteria. Adaptive management should consider the possibility operating the NDD such that the first flush, which contains a large sediment load, is not exported.

5. How well does the Effects Analysis describe how conflicting model results and analyses in the technical appendices are interpreted?

Summary

The Effects Analysis covers a multitude of topics. Each panelist gave input into Question 5 based on their areas of expertise.

Hydrodynamics

Hydrodynamic models are sensitive to how the open water regions are represented and how they are connected to the adjacent channels. Because the panel was not provided the bathymetric configuration of the Restoration Opportunity Areas or the order in which the Restoration Opportunity Areas were established, it is not feasible to evaluate the sensitivity of the models to the placement of the Restoration Opportunity Areas. DSM2 (1-D) and RMA/TRIM (mult-D) hydrodynamic models represent Restoration Opportunity Areas differently. This could be a significant source of error, especially when Delta Cross Channel gates configuration is open.

Life cycle models: winter Chinook salmon

No formal comparison of output from the OBAN and IOS models was provided, either on an absolute scale or relative scale. It should be acknowledged that adult escapement differs between models by a factor of 5. Through-Delta survival projects were also fractionally different between models. In neither case was an explanation for the discrepancy provided. The relative ranking of the different BDCP scenarios (Table 5.G-2) between models should be provided in the report, and certainly should be assessed, in part, based on the degree of consistency in predictions of the BDCP scenario ranks between models.

Salmonids: Delta Passage Model

For salmonids, the Delta Passage Model Salvage Estimates and the Salvage Density methods produced reasonably consistent estimates. Variance calculations need to be corrected. There appear to be analytical errors in expressing uncertainty.

Salmonids: Temperature Model

The text is not clear how the models predict these changes associated with the BDCP during egg incubation, if the BDCP has no effect on upstream conditions, as reported in sections of Chapter 5. In spite of these conflicting results, Figure 5.5.4-1 shows that there would be zero effect on eggs in the Sacramento River with moderate to high certainty in this conclusion. This evaluation needs clarification and should be consistent with the Appendix.

Terrestrial Species

Suitable habitat for each species in the Plan Area was based on expert opinion and therefore there are no model results to interpret. The plan adequately addresses conflicting estimates of the number of sandhill cranes that may be killed by collisions with powerlines.

Recommendations

Covered fish

- A direct comparison of the output from competing models should be presented.
- Clarify confusing and conflicting text related to salmon models.
- Explanation for the large discrepancies in predictions in adult returns (i.e., factor of 5) should be provided and possible consequences to Effects Analysis. Use of relative effects does not eliminate systematic biases of models.

Hydrodynamics

- Identify which Restoration Opportunity Areas are represented differently between the DSM2 and the RMA/TRIM models, especially in the Mokelumne system, which is sensitive to Delta Cross Channel operations.
- Publications from that CASCaDE (<http://cascade.wr.usgs.gov/index.shtm>) would be resources to guide the evaluation of propagation errors in the BDCP Effects Analysis.

Comments

Life-cycle models

When discussing IOS and OBAN life cycle modeling results, the Effects Analysis stated:

"The results of both models suggest future climate change effects would dominate changes in adult winter-run Chinook salmon escapement in the future, which is of appreciable concern for the species. Factoring in climate change, relatively small differences in upstream conditions between the BDCP LLT scenarios and EBC2_LLТ resulted in greater adult escapement under HOS_LLТ or lower adult escapement under ESO_LLТ and LOS_LLТ. These results reflect what appears to be appreciable model sensitivity to relatively small changes in estimated upstream conditions because, as noted above, the BDCP does not change Shasta Reservoir and upper Sacramento River operating criteria, so that changes in upstream areas derived from modeling, be they positive or negative, may not be fully reflective of the nature of actual changes that could occur." (pg. 5.5.3-45, lines 38-46)

The above statement about climate change impacts on Chinook abundance is clear and noteworthy, but the text below it is confusing and should be clarified (did the model receive inaccurate information for upstream conditions?).

Chinook salmon

For egg incubation of spring Chinook, Chapter 5 describes conflicting results (pg. 5.5.4-14). The text states, "Several models show no change in upstream condition as a result of BDCP". In the same paragraph, it states that SacEFT predicts a 12% reduction in egg incubation "condition" based on water temperature effects on egg survival. In contrast, the Reclamation Egg Mortality model predicts no effect due to the BDCP except in below normal water years (12% reduction in survival). SALMOD predicts negligible impacts of the BDCP on eggs, fry and smolt. The text concludes that the adverse impacts are related to high sensitivity of some models to small changes in upstream conditions. The text is not clear when describing how the models might predict these changes during egg incubation, if the BDCP has no effect on upstream conditions as reported in portions of Chapter 5. In spite of these conflicting results, Figure 5.5.4-1 shows that there would be zero effect on eggs in the Sacramento River with moderate to high certainty in this conclusion. This evaluation needs clarification.

- Habitat and flow modeling efforts in the Delta were not linked. As noted above, habitat suitability modeling indicates somewhat large habitat increases for foraging salmonids in response to restoration activities. However, these estimates of habitat did not account for reduced flows that would occur when juvenile salmonids are present in the Delta area, especially in wet years. In other words, will reduced BDCP flows affect access by juvenile salmonids to the habitat identified in Table 5.5.3-4, or do tidal fluctuations overwhelm river flows in all of these habitats?

Lack of consideration of propagation of errors or sensitivity analysis in linked models

A direct comparison of the output from competing models is rarely presented. Results from different models are rarely formally compared on either an absolute or a relative scale. When different models projections exist, the BDCP rarely attempts to explain why the discrepancies are occurring or describe the direction of the expected errors.

Uncertainty plus more uncertainty produces even more uncertainty. Uncertainty never averages or cancels uncertainty any more than noise plus additional noise produces less noise. The propagation of errors will not be a simple sum of uncertainties in most cases. One can use variance in stages formula

$$Var(\hat{\theta}) = E_2[Var_1(\hat{\theta}|2)] + Var_2[E_1(\hat{\theta}|2)]$$

to propagate errors over multiple processes or sequentially linked models and where 1 and 2 denote sources of error in estimating the parameter θ by $\hat{\theta}$. Levels of uncertainty have different credence depending on the importance of biological stressors or attributes. An assessment might have high uncertainty for all low-importance attributes and still have overall high certainty if all the important attributes carry with them high certainty. Conversely, the overall assessment would have low certainty if one or more high-importance attributes carry high uncertainty. Overall uncertainty will never be less than the highest level of uncertainty for the more important biological attribute being considered.

There are several different cases in the Effects Analysis where multiple models are linked together. Each model has inherent errors either due to assumptions made in the modeling or numerical method errors. One of the best examples of how to link models in the Delta system is the U.S. Geological Survey's CASCaDE project (<http://cascade.wr.usgs.gov/index.shtml>). Publications from that project would be resources to guide the evaluation of propagation errors in the BDCP Effects Analysis.

The assumptions made in hydrodynamic models TRIM/ RMA versus DSM2 or CALSIM2 result in a range of outcomes; their analysis is limited to only one set of ROA configurations

During the hydrodynamics presentation on 1/28, the calibration of the DSM2 (1-D) model compared to the TRIM/RMA (multi-d) models showed that the models agreed better when the Delta Cross Channel was closed than when the Delta Cross Channel was open. When the Delta Cross Channel is open, transport is influenced more by the circulation in the Mokelumne channels on the east side of the Delta.

The fact that the two models do not match well when the Delta Cross Channel is open indicates that the representation of Restoration Opportunity Areas is different between the 1-D and 2-D models. Hydrodynamic models are sensitive to how the open water regions are represented and how they are connected to the adjacent channels.

Because the panel was not provided the bathymetric configuration of the Restoration Opportunity Areas or the order in which the Restoration Opportunity Areas were established, it is not feasible to evaluate the sensitivity of the models to the placement of the Restoration Opportunity Areas.

6. How well does the Effects Analysis link to the adaptive management plan and associated monitoring programs?

Summary

While the adaptive management plan is considerably more developed in the BDCP Phase 3, it remains characterized as a silver bullet but without clear articulation about exactly how key assumptions will be vetted or uncertainties resolved to the point that the BDCP goals and objectives are more assured. The concept of adaptive management is appropriately described and allocated a prominent role in the implementation structure. However, as is increasingly documented, the commonly acknowledged process of adaptive management continues to be misunderstood and misapplied (Allen *et al.* 2011; Fontaine 2011; Westgate *et al.* 2013), often resulting in a loss of rigor and commitment in application. The consequence hasn't improved much since Walter's (1986) description of the adaptive management process as beginning:

"...with the central tenet that management involves a continual learning process that cannot conveniently be separated into functions like research and ongoing regulatory activities, and probably never converges to a state of blissful equilibrium involving full knowledge and optimum productivity."

In the case of the uncertainties surrounding the assumptions and predictions of the BDCP, the Panel emphasizes that BDCP needs to recognize the risks of **not** institutionalizing an exceedingly rigorous adaptive management process in order to avoid ecological surprises that will be difficult or impossible to reverse once they have

established (Lindenmayer *et al.* 2010; Westgate *et al.* 2013). BDCP must make a commitment to the fundamental process, and specifically the required monitoring, not just the concept of adaptive management. As Murphy and Weiland (2014) counsel:

"...adaptive management that targets listed species represents a complex process that can be resource intensive, including in its demand for guidance from research, monitoring, and modeling, therefore requiring substantial technical and institutional capacity. That considered, adaptive management has a great potential to improve the effectiveness and efficacy of resource management actions provided it is properly implemented."

In the final assessment of the Effects Analysis, the Panel found the cautionary conclusion of Olden *et al.* (2014) about large-scale flow experiments to be particularly germane:

"...managers and policy makers must embrace both the scientific uncertainty and surprise learning opportunities that inevitably arise from these experiments, and not purposely ignore uncertainty to avoid complicating their message to stakeholders, only to later invoke this issue when flow experiments fail to deliver expected ecological or social outcomes."

Recommendations

- The Effects Analysis effectively communicates the important principles and implementation stages of adaptive management, but the specific process whereby adaptive management would be utilized to ensure BDCP meets its goals and objectives by rigorous adaptive management need to be described in much more detail. There needs to be a more obvious commitment to active adaptive management.
- There is explicit linkage between key uncertainties underlying the assumptions of the Effects Analysis and the monitoring and research that need to address them through adaptive management. However, many of the critically uncertain ecosystem processes, population responses, etc. that are identified as adaptive management targets are delegated to research, rather than monitoring. Any metric upon which decisions about the expected or predicted performance of a management measure will be made should be a foundational monitoring metric, not a focus of research, which is often vulnerable to competing priorities.
- To facilitate an active adaptive management plan that has some chance of ensuring the beneficial result of BDCP conservation measures, each and every key uncertainty should be "fleshed out" into implementable adaptive management "experiments" where the following are specifically described: (1) a conceptual model, or components of an existing model, that characterizes the uncertainty and what it influences; (2) assessment of the relationship between the uncertainty and the BDCP goals and objectives; (3) sensitivity of the proposed implementation to the uncertainty; (4) success criteria, monitoring metrics, baseline levels, thresholds and trigger points that will identify whether or when the performance of the conservation measure is deviating significantly from the anticipated target or prediction; (5) alternative hypotheses and how they affect the original conceptual model; and, adaptation of the (6) implementation action or (7) adaptation of the goals and objectives.

- Linkages between scientific development of the Effects Analysis and adaptive management should continue, if not expand, with implementation of the BDCP. At the minimum, consider the necessity to guarantee independent science review at the interface between the Adaptive Management Team and the Implementation Office, to ensure close to real time tracking of adaptive management experiments and decisions.

Comments

Perhaps the largest challenge to achieving the stated goals and objectives of the BDCP is how many of these critical uncertainties can be addressed by adaptive management given the baseline and the required monitoring? For example, some of the key uncertainties identified in the Effects Analysis (Appendix 3.D), often associated with conservation measures 4, 5, 7, and 11, include:

- The ability of the restored habitat to meet the objectives and expected outcomes, including the time it takes to meet the biological objectives. (Can this be addressed by both magnitude and siting of restoration action?)
- The risk that the restored habitat will be colonized by invasive species such as nonnative submerged vegetation, nonnative predatory fish, and/or clams. (Hardly uncertain, but controllable?)
- The change in magnitude of predation mortality on covered fish. (Doesn't this require an existing reliable estimated of predation mortality?)
- Food web responses to habitat restoration actions on both a local and a regional scale.
- The risk of adverse effects resulting from unsuitable changes in water quality and exposure to toxic contaminants. (How much can be modeled?)
- The proportion of the covered species population that actively inhabit restored habitats and the change in growth rate, survival, abundance, life-history strategies, and population dynamics. (A very difficult baseline to quantify!)

The Effects Analysis provided explicit associations of such key uncertainties with each conservation measure and linked these to "potential research actions" (BDCP, Table 3.D-3).

The context of a "phased approach to serve as a large-scale experimental program" in adaptive management context implies conceptual models, baselines and thresholds?

Linkages between scientific development of the Effects Analysis and adaptive management should continue, if not expand, with implementation of the BDCP. In particular, it will be important to ensure that there is direct science input to the adaptive management process, and preferably an independent science body that has no conflict of interest in interpreting and adapting conservation measures. In the proposed implementation structure, the Science Manager chairs the Adaptive Management Team and coordinates with the Delta Science Program, and the Delta Independent Science Board may also be consulted about "...matters relating to these monitoring activities and research efforts." (Chap. 7-25, pp. 7-25). However, the Delta Independent Science Board is not engaged to the extent that they could deal with extensive monitoring and research results and adaptive management decisions in real time. We would doubt that the adaptive management process would be efficient, timely and evaluated without an

independent scientific advisory body that reports to the Adaptive Management Team, Science Manager, Program Manager and the Delta Science Program.

Review of Specific Analyses

7. Are the analyses related to the north Delta diversion facilities appropriate and does the Effects Analysis reasonably describe the results? In particular:

Q. Was existing empirical information such as Perry *et al.* 2010 and Newman 2003 incorporated appropriately into the modeling? Where model runs required extrapolation beyond existing data ranges, were assumptions and interpretations appropriate?

Summary

The empirical information in Perry (2010) and Newman (2003) must be guardedly and cautiously applied in the modeling in future cases when north Delta diversion is operational. These empirical relationships are based on the best available information regarding current physical and operational configuration of the Delta. We assessed the validity of four model assumptions. The panel concluded: 1) the assumption of a 3-day moving average to characterize flow on the Sacramento below Georgiana Slough is not valid in the new configuration, 2) exporting water at the north Delta diversion facilities will change circulation patterns at the important north Delta channel junctions (i.e. Steamboat, Sutter, Delta Cross Channel, Georgiana), 3) an additional transfer point out of the Sacramento at the north Delta diversion will alter the empirical relationship, and 4) there are issues with original assumptions in Newman (2003). The concerns raised above, at best, add additional uncertainty to the conclusion drawn by BDCP. At worst, these concerns may result in systematic biases in the model projections. The direction of the net effect of these biases is unknown.

Recommendations

- Consult with Russell Perry and Ken Newman on their perspectives regarding the applicability of their models to the Effects Assessment.
- Perform more hydrographic modeling below the anticipated north Delta diversion to determine whether the nature of the outflow will violate assumptions or parameterizations of the Perry (2010) model and alter model output.
- Additive simulations should be performed varying the parameterization and possible structure of the relationships with Perry (2010) and Newman (2003) to determine robustness of the model results to changes in Sacramento River outflow under the BDCP.

Comments

The empirical relationships, derived in Perry (2010) and Newman (2003), are based on the best available information regarding current physical and operational configuration of the Delta. For these relationships to be useful, they also need to describe the Delta under BDCP. To assess the validity of these relationships, we must examine how the system will change with the addition of the north Delta diversion. There are four primary

sets of questions to address: 1) Will the system continue to have a “quasi-steady state” condition or will the timescale of flow variance change? Is a 3-day moving average to characterize flow on the Sacramento below Georgiana Slough a legitimate assumption?, 2) Will the circulation patterns change at the important channel junctions (i.e., Steamboat, Sutter, Delta Cross Channel, Georgiana) as a result of north Delta diversion operations?, 3) Will the north Delta diversion be another transfer point out of the Sacramento river migration corridor?, and 4) Are the assumptions used in the original analysis valid?

Will the system continue to have a “quasi-steady state” condition or will the timescale of flow variance change as the result of north Delta diversion operations?

In the current configuration of the system, the north Delta is in a quasi-steady state. In general, flows on the Sacramento at Freeport change slowly over time (i.e., on the order of days). The only operation that can dramatically alter circulation patterns is the opening or closing of the Delta Cross Channel gates. The position of this gate is not frequently changed. And, when changed, the system reaches a different quasi-steady state condition after about a day. A visual example of this step change is found in Perry (2010, Fig. 3). Therefore, the assumption of a three-day moving average to characterize flow on the Sacramento below Georgiana Slough seems reasonable for the current configuration (flow and operations) of the North Delta.

When the north Delta diversion facilities become operational, the North Delta will no longer be in a quasi-steady state condition. The flows will behave more like what is currently observed in the South Delta as the pumping will not be continuous throughout the day. And, pump volume will also change at least daily. The timescale of flow variance will change more rapidly over time (i.e., on the order of hours). Therefore, the three-day moving average flow assumption is not valid in the new configuration with the north Delta diversion.

Will the circulation patterns change at the important channel junctions (i.e., Steamboat, Sutter, Delta Cross Channel, and Georgiana) as a result of north Delta diversion operations?

We know that opening and closing the Delta Cross Channel changes the circulation patterns in the north Delta. Exporting water at the north Delta diversion facilities will also change circulation patterns at the important channel junctions (i.e., Steamboat, Sutter, Delta Cross Channel, Georgiana). The DSM2-Hydro simulations that were used for the analysis of this issue in section 5C.5.3.5 are capable of outputting data even on a 15 minute time step. This model resolution should be able to quantify these differences. If the circulation patterns change, the proportion of fish distributed to each downstream channel will be altered as well. Therefore, the empirical relationship created for the current configuration of the Delta is not valid for the future configuration.

Will the north Delta diversion be another transfer point out of the Sacramento migration corridor?

Throughout the analysis in 5C.5.3.5, there is an assumption of zero entrainment of as a result of 100% effective diversion screens. However, the north Delta diversion will be pumping water. Therefore, empirical relationship between the flow at Sacramento below

Georgiana and the number of fish present will be different from the current empirical relationship using the current (no north Delta diversion) configuration.

In addition, the validity of the primary assumption that there will be no entrainment of fish at the north Delta diversion should be evaluated. In reality, there will be some fish lost at the transfer point, therefore, the empirical relationship would be altered including this additional transfer point.

Are the assumptions used in the original analysis valid?

Newman (2003), Table 2 presents a summary of the covariates used in his modeling. There are two columns, mean and sample standard deviation. In this table, he reports a mean value for Delta Cross Channel gates of 0.61 with a sample standard deviation of 0.49. The Delta Cross Channel gate signal is a binary signal. It should be either open (1) or closed (0). Under no circumstances should that variable be reported as something other than 0 or 1. This analysis should have been broken into two time periods: gate open and gate closed conditions. This table raises a significant concern that the author did not have a basic understanding of how the Delta Cross Channel gate changes flow patterns (and migration patterns) in the Delta.

The concerns raised above, at best, add additional uncertainty to the conclusion drawn by the Plan. At worst, these concerns may result in systematic biases in the model projections. The direction of the net effect of these biases is unknown.

Q. Does the analysis of the frequency of reverse flows at Georgiana Slough accurately characterize changes in hydrodynamics due to changes in river stage, sea level rise, and Delta habitat restoration?

Modified question based on 1/29/2014 meeting discussion: Will the operation of the north Delta diversion change the circulation patterns around the Sacramento junctions with the Delta Cross Channel and Georgiana Slough such that fish (particularly migrating fish) have a higher likelihood of being diverted into the interior of the Delta via Georgiana Slough or the Delta Cross Channel due to tidal flood/ebb flows in this region?

Summary

We know, based on long-term field observations and hydrodynamic modeling, that the transition point from uni-directional flow and bi-directional flow at the tidal timescale occurs somewhere between Sacramento River above the Delta Cross Channel (RSAC128) and Sacramento River below Georgiana (RSAC123) for the current configuration and operations of the Delta. The operation of the north Delta diversion facility will reduce the amount of freshwater flow in the region of the Delta Cross Channel and Georgiana junctions. Hydrodynamic modeling will likely show that transition point between uni-directional and bi-directional flow will move upstream as a result of north Delta diversion operations. This transition location is also a function of whether the Delta Cross Channel is open or closed. If bi-directional flow occurs more frequently near the Sacramento junctions with the Delta Cross Channel and Georgiana Slough, fish will have a higher likelihood of being diverted into the interior of the Delta via Georgiana Slough or the Delta Cross Channel.

Recommendations

The DSM2 simulations should be re-run for the ELT and LLT simulations with bathymetry that does not include the Restoration Opportunity Areas but driven with ELT or LLT river flow and tidal stage boundary conditions and operations. These simulations would clearly show how north Delta diversion operations change circulation patterns near Georgiana Slough and the Delta Cross Channel.

Comments

During the Effects Analysis Panel presentation on 1/29/2014, one of the Panel members (N. Monsen) asked for clarification of Question 7b. Based on that discussion, we concluded that the main questions that the Fish Agencies would like to see the panel address were:

"Will the operation of the north Delta diversion change the circulation patterns around the Sacramento junctions with the Delta Cross Channel and Georgiana Slough such that fish (particularly migrating fish) have a higher likelihood of being diverted into the interior of the Delta via Georgiana Slough or the Delta Cross channel due to tidal flood/ebb flows in this region?"

"Will this change in flow regime as a result of north Delta diversion operations result in fish encountering this junction multiple times rather than just once, thus increasing the probability of the fish being diverted into the interior Delta?"

It should be noted that these rephrased questions are very different than what the analysis in Sections 5C.4.3.2.6 and Section 5C.5.3.8.1 of the Effects Analysis addressed. The following suggest an approach to answer the modified question and comment on the analysis in Sections 5C.4.3.2.6 and Section 5C.5.3.8.1.

Part A: Suggested approach to address the modified 7b question

For this discussion, please refer to the Draft Environmental Impact Report/Environmental Impact Statement Appendix 5A that has examples of observed tidal stage and flow time series data from three key locations along the Sacramento River (Appendix C of this document).

The Sacramento River throughout the Delta has a tidal signal for both stage and flow. The Sacramento observation station at Freeport (RSAC155), above the proposed north Delta diversion intakes, has a tidal flow signal (Appendix 5A-D1, p. 128). At Freeport, both the tidal and tidally-averaged flow is always uni-directional downstream. Therefore, a neutrally-buoyant particle going with the flow at this location will always be traveling downstream, although the velocity at which it moves is dependent on the phase of the tides.

In the current bathymetric configuration and operations of the Delta Cross Channel (no north Delta diversion facilities), the observation station on the Sacramento above the Delta Cross Channel (RSAC128, Appendix 5A-D1, p. 129) also has downstream uni-directional flow both for the tidal and the tidally-averaged timescale. However, the flow signal on the Sacramento below Georgiana Slough (RSAC123, Appendix 5A-D1, p. 130) has reversing tidal flows. Therefore, even though the tidally-averaged flow at RSAC123 is downstream, A particle moving with the velocity field in the region of RSAC123 will flow both upstream and downstream. Therefore, the tidal excursion or range that a neutrally-buoyant particle will move upstream and downstream, at

RSAC123 is important to determine how many times the particle will encounter junctions (such as Georgiana and Delta Cross Channel).

The Sacramento River above the Delta Cross Channel (RSAC128) and the Sacramento River below Georgiana (RSAC123) are only 5 river km apart and yet the flow signals at these stations are very different. These flow signals are distinctly different because there are two junctions, the Delta Cross Channel and Georgiana Slough, between these measurement stations where a portion of the water is diverted towards the Central Delta. The flow signal at RSAC123 also changes depending on whether the Delta Cross Channel is open or closed.

Therefore, we know, based on long-term field observations and hydrodynamic modeling, that the transition point between uni-directional flow and bi-directional flow at the tidal timescale occurs somewhere between RSAC123 and RSAC128 for the current configuration and operations of the Delta.

To determine how the north Delta diversion operations will change circulation patterns around the Delta Cross Channel and Georgiana Slough, the DSM2 model can be used to determine the location along the Sacramento where the flow transitions from unidirectional and bi-directional tidal flows. This transition location will also be a function of whether the Delta Cross Channel is open or closed. It is also useful to determine the extent of tidal excursion to determine whether particles would encounter either the Delta Cross Channel junction or the Georgiana Slough junction multiple times.

The operation of the north Delta diversion facility will reduce the amount of freshwater flow in the region of the Delta Cross Channel and Georgiana junctions. Modeling will likely show that transition point between unidirectional and bi-directional flow will be moved upstream. This transition point may be even as far upstream as RSAC128 (Sacramento above DCC).

Part B: Comments related to the analysis in Sections 5C.4.3.2.6 and 5C.5.3.8.1

The approach taken for the analysis in Sections 5C.4.3.2.6 and 5C.5.3.8.1 focused only on the exchange between the Sacramento River with Georgiana Slough. The approach of analyzing flow direction every 15 minutes was a reasonable approach given the original 7b question. However, the analysis did not attempt to also look at the exchange through the Delta Cross Channel, which should be done for the modified 7b question.

The bigger issue with this particular analysis is the assumed Delta bathymetry used for the ELT and the LLT simulations. For both the ELT and LLT simulations, Restoration Opportunity Areas are included in the bathymetry. The tidal field is significantly changed by the inclusion of these Restoration Opportunity Areas. Note that these Restoration Opportunity Areas are only one possible configuration. As of this BDCP draft, the final locations of the Restoration Opportunity Areas, the order of construction the Restoration Opportunity Areas, and the bathymetric connections between the Restoration Opportunity Areas and the adjacent channels have not been established.

In the BDCP conclusion for this analysis states:

"Ongoing research is investigating link is between the distribution of energy dissipation and the distribution of tidal prism within the context of Plan Area restoration and other factors (DeGeorge pers. comm.). ... it is unknown whether the presently limiting conveyance capacity of a number of Delta channels for tidal

flows may become enlarged by scouring in response to Plan Area changes in geometry resulting from habitat restoration. These factors may have consequences for the hydrodynamics at the Sacramento River-Georgiana Slough divergence and other locations." (5C.53-331, lines 22-29)

This conclusion indicates that the present hydrodynamic modeling does not separate the effects of the north Delta diversion from the preliminary Restoration Opportunity Areas configuration in the ELT and LLT simulations.

One of the best reasons to use hydrodynamic modeling as an analysis tool is that models have the capability of isolating individual effects. The DSM2 simulations should be re-run for the ELT and LLT simulations with bathymetry that does not include the Restoration Opportunity Areas but does have the ELT or LLT river flow and tidal stage boundary conditions and operations. These simulations would clearly show how north Delta diversion operations change circulation patterns near Georgiana Slough and the Delta Cross Channel.

8. How should the effects of changes in Feather River flows on fish spawning and rearing be characterized? In particular, how should the trade-off between higher spring flows and lower summer flows be interpreted? Does the analysis adequately capture the expected benefits of CM 2, Yolo Bypass Fishery Enhancement?

Summary

Chapter 5 correctly recognized that flow/habitat relationships are necessary for evaluating changes in Feather River flow and temperature on salmonids. However, relationships between flow and habitat were not presented in Chapter 5, therefore it was not possible for the Panel to evaluate changes in spawning and rearing habitat. Most salmonids reportedly inhabit the low flow channel which will reportedly experience little change. BDCP effects relate primarily to the fraction of salmonid populations inhabiting the high flow channel plus fish exposure to the high flow reach during upstream and downstream migrations.

Chapter 5 provides a reasonable discussion of the approximate benefits of increasing flow into Yolo Bypass and allowing more juvenile salmon, especially foragers, to utilize this rearing habitat. Potential adverse effects on migrating adults should be monitored.

Recommendations

- Develop flow/habitat relationships for salmonids in the Feather River high flow channel, approximate the proportion of the population that uses this habitat, and correct inconsistencies in the text and summary figure.
- The Yolo Bypass evaluation should recognize that natural origin Chinook salmon have a higher fraction of foraging type juveniles compared with migrant Chinook produced in hatcheries. Natural origin juveniles would likely benefit more than hatchery fish.

SENSORY PROPERTIES AND ANALYSIS OF TWO MUDDY ODOUR COMPOUNDS, GEOSMIN AND 2-METHYLISOBORNEOL, IN WATER AND FISH

PER-EDVIN PERSSON

University of Helsinki, Department of Limnology, Viikki, SF-00710 Helsinki 71, Finland

(Received January 1980)

Abstract—Muddy or earthy odours are a problem in water supplies and fisheries. Some species of aquatic actinomycetes and blue-green algae are generally indicated as sources of muddy odour in natural waters. These organisms are capable of producing the muddy-smelling compounds geosmin and 2-methylisoborneol.

The sensory properties of geosmin and 2-methylisoborneol in water and in the flesh of four species of fish were studied. Threshold odour concentrations are presented, and they indicate that both compounds have strong odour characteristics. The intensity of the muddy odour as perceived by the judges was proportional to the logarithm of the concentration of muddy odour compounds in the concentration ranges tested (for geosmin, up to $100 \mu\text{g kg}^{-1}$, and for 2-methylisoborneol, up to $10 \mu\text{g kg}^{-1}$). The results indicate that it may be possible to quantify muddy odour compounds in water and fish by sensory methods.

INTRODUCTION

Taste and odour problems in drinking water and, to some extent, in fish for human consumption are a common source of complaint of consumers in many countries. The adverse effects of such problems are obvious: a partial list would include high treatment costs for water supplies, reduced aesthetic values of recreational waters, and economic losses to fishermen. There are numerous examples of the practical importance of offensive tastes and odours in water and fish. For instance, a study in The Netherlands (Zoeteman & Piet, 1973) indicated an appreciable reduction (45%) in water consumption due to bad taste of the water (Cees *et al.*, 1974). In Finland, a musty odour episode in fish from the Oulu sea area in 1969 caused severe economic losses to hundreds of fishermen, many of them temporarily losing their jobs (Partanen, 1969; Persson, 1974). Similar cases are known from many other countries as well.

This communication deals specifically with the sensory analysis of one group of odours, namely earthy, muddy and musty odours in water and fish. This odour type is frequently encountered in eutrophic aquatic environments. It has been a common source of trouble among American water works (Middlebrooks, 1965), and it also is the most common type of off-flavour in Finnish fisheries (Persson, 1978).

Earthy or muddy odour problems have been known in water supplies and fisheries for a long time. Recent reviews of the problem are provided by Persson (1977) and Silvey & Roach (1975). Some species of actinomycetes (Adams, 1929; Thaysen, 1936) and blue-green algae (Jackson & Ellms, 1897; Leger, 1910) have been indicated as sources of muddy odour in

water and fish. The findings of the early investigators, based mainly on ecological evidence, have been substantiated by analytical studies since the 1960s (Berglund *et al.*, 1978; Collins *et al.*, 1970; Gerber, 1968; Gerber & Lechevalier, 1965; Henley, 1970; Medsker *et al.*, 1968; Persson, 1979a; Rosen *et al.*, 1968; Safferman *et al.*, 1967; Tabachek & Yurkowski, 1976; Weete *et al.*, 1977).

Some species of actinomycetes and blue-green algae produce compounds with distinct odours. Geosmin (*trans*-1,10-dimethyl-*trans*-9-decalol; Gerber, 1968) has a distinct muddy aroma, reminiscent of decaying reed banks. In concentrated form, 2-methylisoborneol (MIB) alias 1,2,7,7-tetramethyl-*exo*-bicyclo(2.2.1)heptan-2-ol smells like camphor (Gerber, 1969; Medsker *et al.*, 1969), but when diluted the odour is musty (Persson & York, 1978). Geosmin and MIB have been detected in natural waters (Kikuchi *et al.*, 1972; Piet *et al.*, 1972; Rosen *et al.*, 1970). Yurkowski & Tabachek (1974) have identified geosmin in muddy-flavoured rainbow trout (*Salmo gairdneri*). Geosmin has also been identified in some vegetables (Acree *et al.*, 1976; Buttery *et al.*, 1976; Murray *et al.*, 1975), and both geosmin and MIB have been detected in garden soil (Buttery & Garibaldi, 1976).

A rational approach to odour nuisance treatment and abatement requires data on sensory and chemical properties of specific odour compounds. Since sensory evaluation of muddy odours directly measures the nuisance caused by it, Persson & York (1978) attempted a quantification of 2-methylisoborneol in water and fish by sensory methods. The present communication is based on the approach of Persson & York (1978), and represents a continuation of the preliminary work done by them and Persson (1979b,c).

MATERIAL AND METHODS

2-Methylisoborneol was synthesized according to Wood & Snoeyink (1977). A sample of microbiologically produced geosmin (Gerber, 1974) was obtained from the United States Environmental Protection Agency, Water Supply Research Division, Cincinnati, Ohio.

The sensory evaluation was performed according to Persson & York (1978). The work on MIB was done in 1978, and the work on geosmin in 1979. Two panels participated (one in 1978, and one in 1979), both consisting of ten judges (in 1978, 8 female and 2 male judges; in 1979, 5 and 5 respectively). The judges (between 22 and 36 yr of age) were students and research assistants at the Department of Food Chemistry and Technology of the University of Helsinki, and all of them had previous experience of sensory evaluation. They were familiarized with muddy odours in briefing sessions by presenting aqueous solutions of geosmin and MIB for sniffing. Also, pure cultures of muddy-smelling actinomycetes (Persson, 1979a) were sniffed.

The laboratory used was designed for sensory testing. The judges were served in individual booths, and a slight positive air pressure was maintained in the laboratory to prevent outside odours from entering. Air temperature was practically stable throughout the work, but the humidity was not controlled, and may have varied. Sessions were held twice a day, in the mid-morning and the mid-afternoon, respectively. All judges did not participate in all sessions.

The water tested was twice distilled, and test solutions were prepared by adding geosmin or MIB to the water. The judges were asked to indicate the presence or absence of muddy odour when sniffing 50 ml of test liquid at room temperature in 130 ml wide-necked glass jars with ground glass stoppers. The judges were also asked to indicate the intensity of the muddy odour on a graphical scale printed on the test sheets, with end points arbitrarily fixed at 0 and 50, respectively, and with anchor points given as follows: very weak (4), moderate (25), and very strong (46). The samples were coded by three-digit random numbers. The solutions were sniffed in ascending order and blanks were included in the series. The judges were asked to wait 30 s before proceeding from one sample to the next. As reference, twice distilled water was used. In one session, about 10 ml of liquid in small wide-necked containers was used.

Geosmin and MIB were also added to minced flesh of fish. The following species of fish were tested: bream (*Abramis brama*), pike (*Esox lucius*), pikeperch (*Lucioperca lucioperca*), and rainbow trout (*Salmo gairdneri*). The fish samples (about 15 g) were individually wrapped in aluminium foil, coded by three-digit random numbers, cooked in steam without seasoning and submitted for sensory evaluation while hot. The same test sheets as for water were used. In a separate test, fish used for the preparation of samples were found to be free of any taint. For the addition of geosmin and MIB to the fish ethanol solutions were used. In addition to reference fish (fish of good quality), a

Table 1. Threshold odour concentrations ($\mu\text{g kg}^{-1}$) of geosmin and MIB in water and fish

	Geosmin	MIB
Water	0.015*	0.042†
Bream (<i>Abramis brama</i>)	0.90	0.095
Pike (<i>Esox lucius</i>)	0.59	0.085
Pikeperch (<i>Lucioperca lucioperca</i>)	—‡	0.075
Rainbow trout (<i>Salmo gairdneri</i>)	6.5	0.55

* Persson (1979c). † Persson (1979b). ‡ Not determined.

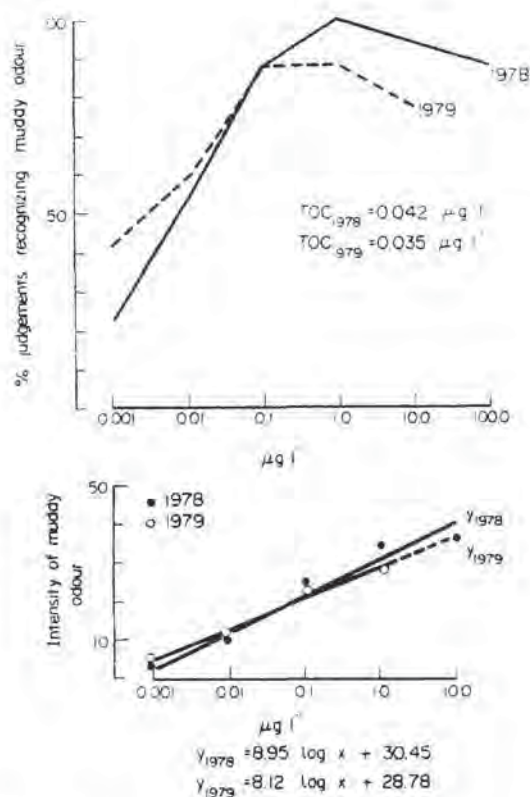


Fig. 1. Comparison of the sensory response of the two panels participating in the study. Recognition thresholds of muddy odour of MIB in water (above), and the intensity of the muddy odour as a function of the concentration of MIB (below) for the two panels working in 1978, and 1979, respectively (data from Persson, 1979b).

blank containing only the ethanol addition was included in the series tested.

In this work the threshold odour concentration (TOC) is defined as the concentration recognized as muddy by 75% of the judgements. This corresponds to a 50% correct recognition, excluding correct answers obtained by chance. The threshold odour concentrations were determined graphically from a semi-logarithmic plot of the relative frequency (%) of judgements recognizing muddy odour versus the concentration of the muddy odour compounds.

RESULTS AND DISCUSSION

Threshold odour concentrations (TOC)

Threshold odour concentrations of geosmin and MIB in water and fish are presented in Table 1.

Since the TOCs of geosmin and MIB were obtained by different panels, a comparison of their response to MIB is presented in Fig. 1. The response was very similar, indicating that the results of the panels are comparable to each other. The diminished response for muddy odour recognition in the high concentration range ($\geq 10.0 \mu\text{g l}^{-1}$, Fig. 1) was partially due to the change in the odour character of MIB from muddy/musty to camphorous (Persson & York, 1978).

The panel TOCs of geosmin and MIB in water (Table 1; Fig. 1) may be compared to the frequency distribution of individual TOCs in Fig. 2. The variation in individual TOCs was large, and sometimes

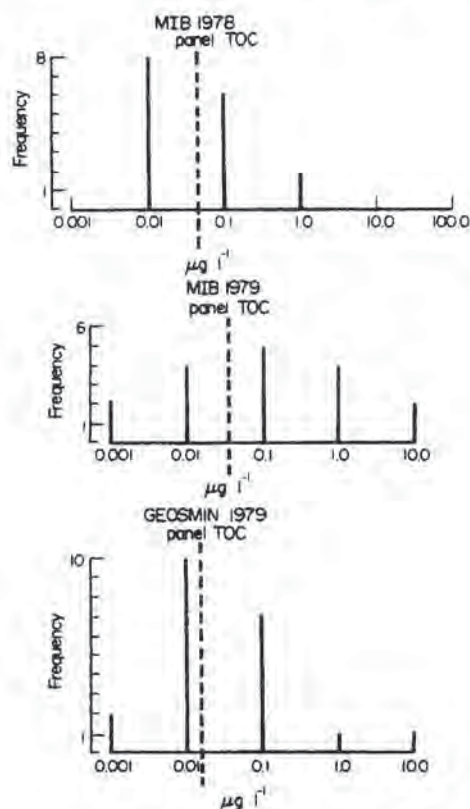


Fig. 2. Frequency distribution of individual TOCs of all judges (including repetitions) for geosmin and MIB in water.

the TOC of one judge varied from one session to another. Nevertheless, the panel TOC in each case was close to the mode of the distribution of individual TOCs. Similar diagrams can be presented for the fish experiments. These results indicate that the TOCs reported in Table 1 may be considered representative of the panel population.

The threshold odour concentrations of geosmin and MIB are, as expected, higher in the flesh of fish than in water. A comparison to data found in the literature (Table 2) indicates a fair amount of variation in TOCs reported. However, some variability between panels and panel sessions even under identical conditions should be expected (Persson, 1979b). The data of Table 2 were obtained under different experimental conditions in different laboratories. Also, the TOCs have been defined in different ways. For instance, the data by Lillard & Powers (1975) in Table 2 represent geometrical means of TOC of individual judges, and are thus not directly comparable to the TOCs in Table 1.

There evidently has been little work on the TOCs of geosmin and MIB in fish. The threshold odour concentration reported by Yurkowski & Tabachek (1974) for geosmin in rainbow trout, $0.6 \mu\text{g } 100 \text{ g}^{-1}$, is almost identical to the TOC obtained in this study ($6.5 \mu\text{g kg}^{-1}$). Generally, the data in Table 1 indicate that the TOCs of geosmin and MIB in rainbow trout

are considerably higher than the TOCs for the other species of fish tested, which may be explained by the very distinct natural flavour of rainbow trout compared to bream, pike and pikeperch. Table 1 also indicates that the TOCs of geosmin in fish are higher than those of MIB in fish, implying that geosmin is more effectively masked by the natural flavour of fish than is MIB. This may also indicate a higher natural background level of geosmin in the flesh of fish compared to MIB.

Sensory Analysis

The muddy odour intensity of geosmin (Fig. 3) and MIB (Fig. 4) was proportional to the logarithm of the concentration of the compounds for a wide concentration range. The muddy odour intensities scored for the reference fish and the ethanol blanks were low (below the lowest concentration of muddy odour compounds tested). The results of Fig. 3 and 4 indicate that it is possible to use sensory methods for a direct quantification of muddy odour compounds when the specific compounds are known. It is, of course, necessary to construct calibration curves of the kind indicated in Figs 3 and 4 for each panel in use. It may even be necessary to construct calibration curves for every panel session separately (Persson, 1979b). Compared to the tedious procedure for analyzing muddy odour compounds in biological material by chemical methods, e.g. geosmin in fish (Yurkowski & Tabachek, 1974), this seems fairly easy.

When working with specific compounds, the TOC values in Table 1 may be compared to detection limits currently available by chemical methods. Rosen *et al.* (1970) reported concentrations of $0.9 \mu\text{g l}^{-1}$ geosmin in water. Wood & Snoeyink (1977) were able to analyze MIB in water down to their TOC, $0.1 \mu\text{g l}^{-1}$. The

Table 2. Threshold odour concentrations of geosmin and MIB reported in the literature

Threshold odour concentration	Reference
<i>Geosmin in water</i>	
$0.2 \mu\text{g l}^{-1}$	Safferman <i>et al.</i> (1967)
$0.13 \mu\text{g kg}^{-1}$	Lillard & Powers (1975)
$0.05 \mu\text{g l}^{-1}$	Medsker <i>et al.</i> (1968)
$0.021 \mu\text{g kg}^{-1}$	Buttery <i>et al.</i> (1976)
$0.015 \mu\text{g kg}^{-1}$	Van Gemert & Nettenbreijer (1977)
<i>Geosmin in rainbow trout</i>	
$0.6 \mu\text{g } 100 \text{ g}^{-1}$	Yurkowski & Tabachek (1974)
<i>Geosmin in beans</i>	
$1 \mu\text{g kg}^{-1}$	Buttery <i>et al.</i> (1976)
<i>MIB in water</i>	
$0.1 \mu\text{g l}^{-1}$	Medsker <i>et al.</i> (1969), Wood & Snoeyink (1977)
$0.1 \mu\text{g l}^{-1}$	Rosen <i>et al.</i> (1970)
$0.02 \mu\text{g kg}^{-1}$	Van Gemert & Nettenbreijer (1977)
$0.018\text{--}0.020 \mu\text{g l}^{-1}$	Persson & York (1978)
<i>MIB in pike</i>	
$0.07 \mu\text{g kg}^{-1}$	Persson & York (1978)

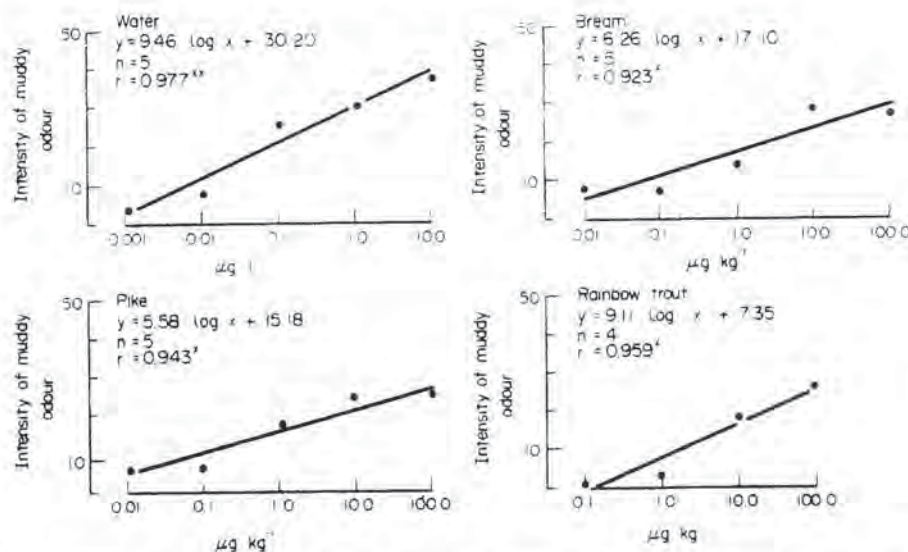


Fig. 3. Intensity of muddy odour in water and the flesh of fish as a function of the concentration of geosmin. Data for water from Persson (1979c).

method of Yurkowski & Tabachek (1974) worked excellently with concentrations of the order a few micrograms geosmin kg^{-1} rainbow trout. Buttery & Garibaldi (1976) analyzed concentrations of $1 \mu\text{g}$ geosmin kg^{-1} and $4 \mu\text{g}$ MIB kg^{-1} garden soil. Evidently, the sensitivity of the human nose still exceeds the sensitivity of chemical methods currently used for the analysis of muddy odour compounds.

However, muddy or earthy odours may be caused by several different chemicals. Cadin-4-ene-1-ol, isolated from actinomycetes, has a woody-earthy aroma (Gerber, 1971). Some alkyl-substituted alkoxy-pyrazines exhibit musty or earthy odours (Parliment & Epstein, 1973; Seifert *et al.*, 1970). 2-Methoxy-3-isopropylpyrazine has been indicated as responsible for the earthy aroma of potatoes (Buttery & Ling,

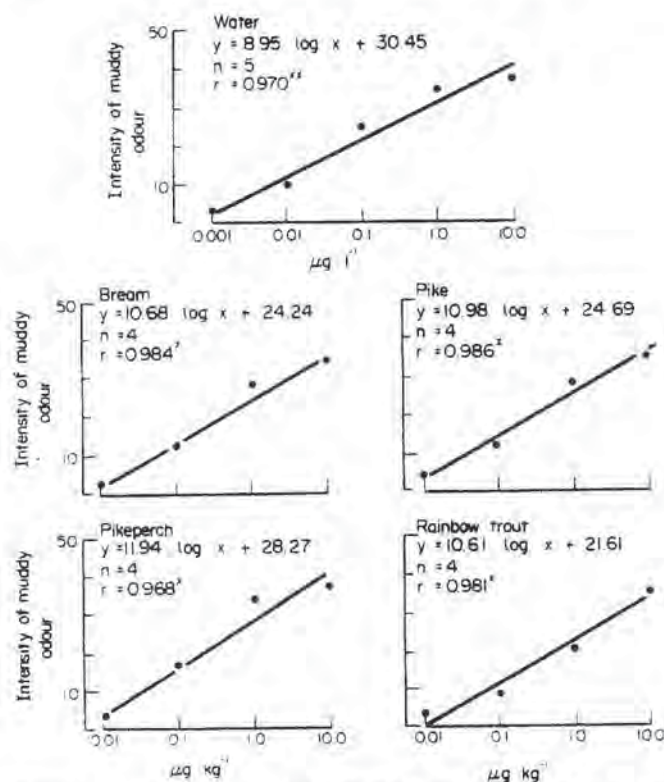


Fig. 4. Intensity of muddy odour in water and the flesh of fish as a function of the concentration of MIB. Data for water from Persson (1979b); data for pike from Persson & York (1978).

1973), and has recently been isolated from a streptomycete (Gerber, 1977). Some chloroanisoles exhibit musty odours (Griffiths, 1974), and have been indicated as a cause of musty off-flavours in chicken and eggs (Bemelmans & de Brauw, 1974; Curtis *et al.*, 1974). Moreover, recently Polak *et al.* (1978) have shown that the earthy odour of geosmin is shared by two other alcohols possessing a partial geosmin structure. Furthermore, they noted that discrimination between earthy odorants decreased with decreasing concentration. Thus, interference by several compounds contributing to an overall muddy odour may limit the general applicability of sensory methods for the quantitation of muddy odour.

In preliminary differentiation tests run on geosmin and MIB in water in this study, the 1979 panel was able to discriminate between geosmin and MIB down to $0.05 \mu\text{g l}^{-1}$. Thus, below this concentration the exact cause of the muddy odour would have been unknown, i.e. the recognition thresholds of specific compounds are higher than the recognition thresholds of the odour character (cf. Table 1).

Acknowledgements—The 2-methylisoborneol used in this study was synthesized at the Freshwater Institute, Winnipeg, Canada, during the author's stay there. The geosmin was produced by Dr N. N. Gerber, Rutgers State University, New Jersey. The rest of the work has been done at the University of Helsinki, Finland, where it has been funded by the Finnish Culture Foundation (Suomen kulttuurirahasto), the Maj and Tor Nessling Foundation, the Academy of Finland, and the University of Helsinki.

I am grateful to Dr M. Yurkowski, Freshwater Institute, Winnipeg, Canada, for supervising the synthesis of MIB; to Mr A. A. Stevens, United States Environmental Protection Agency, Municipal Environmental Research Laboratory, Cincinnati, Ohio, for providing the sample of geosmin; to Associate Professor R. Kurkela, University of Helsinki, for providing the facilities for sensory testing; to the panel participants; and to Ms K. Sivonen, University of Helsinki, for technical assistance. Furthermore, I thank Professor R. Ryhänen and Professor R. Kurkela, University of Helsinki, for helpful criticism of the manuscript.

REFERENCES

- Acree T. E., Lee C. Y., Butts R. M. & Barnard J. (1976) Geosmin, the earthy component of table beet odor. *J. agric. Fd Chem.* **24**, 430–431.
- Adams B. A. (1929) The *Cladothrix dichotoma* and allied organisms as a cause of an "indeterminate" taste in chlorinated water. *Wat. & Wat. Engng* **31**, 327–329.
- Bemelmans J. M. H. & ten Noever de Brauw M. C. (1974) Chloroanisoles as off-flavor components in eggs and broilers. *J. agric. Fd Chem.* **22**, 1137–1138.
- Berglund L., Skulberg O. M. & Gjessing E. (1978) Undersökelse av lukt- og smakskomponenter i algeholdig drikkevann. *Norsk Institutt for Vannforskning*, XK-18.
- Buttery R. G. & Garibaldi J. A. (1976) Geosmin and methylisoborneol in garden soil. *J. agric. Fd Chem.* **24**, 1246–1247.
- Buttery R. G. & Ling L. C. (1973) Earthy aroma of potatoes. *J. agric. Fd Chem.* **21**, 745–746.
- Buttery R. G., Guadagni D. G. & Ling L. C. (1976) Geosmin, a musty off-flavor of dry beans. *J. agric. Fd Chem.* **24**, 419–420.
- Cees B., Zoeteman J. & Piet G. J. (1974) Cause and identification of taste and odour compounds in water. *Sci. Total Environ.* **3**, 103–115.
- Collins R. P., Knaak L. E. & Soboslai J. W. (1970) Production of geosmin and 2-exo-hydroxy-2-methylbornane by *Streptomyces odorifer*. *Lloydia* **33**, 199–200.
- Curtis R. F., Dennis C., Gee J. M., Gee M. G., Griffiths N. M., Land D. G., Peel J. L. & Robinson D. (1974) Chloroanisoles as a cause of musty taint in chickens and their microbiological formation from chlorophenols in broiler house litters. *J. Sci. Fd. Agric.* **25**, 811–828.
- Gerber N. N. (1968) Geosmin, from micro-organisms, is *trans*-1,10-dimethyl-*trans*-9-decalol. *Tetrahedron Lett.* **25**, 2971–2974.
- Gerber N. N. (1969) A volatile metabolite of actinomycetes, 2-methylisoborneol. *J. Antibiot., Tokyo* **22**, 508–509.
- Gerber N. N. (1971) Sesquiterpenoids from actinomycetes: cadin-4-ene-1-ol. *Phytochemistry* **10**, 185–189.
- Gerber N. N. (1974) Microbiological production of geosmin. National Environmental Research Center, United States Environmental Protection Agency, Cincinnati, Ohio, *Environmental Protection Technology Series*, EPA-670/2-74-094.
- Gerber N. N. (1977) Three highly odorous metabolites from an actinomycete: 2-isopropyl-3-methoxypyrazine, methylisoborneol, and geosmin. *J. chem. Ecol.* **3**, 475–482.
- Gerber N. N. & Lechevalier H. A. (1965) Geosmin, an earthy-smelling substance isolated from actinomycetes. *Appl. Microbiol.* **13**, 935–938.
- Griffiths N. M. (1974) Sensory properties of the chloroanisoles. *Chemical Senses and Flavour*, **1**, 187–195.
- Henley D. E. (1970) *Odorous Metabolite and Other Selected Studies of Cyanophyta*. Ph.D. Diss., North Texas State University, Denton, Texas.
- Jackson D. D. & Ellms J. W. (1897) On odors and tastes of surface waters, with special reference to *Anabaena*, a microscopical organism found in certain water supplies of Massachusetts. *Technol. Q.* **10**, 410–420.
- Kikuchi T., Mimura T. & Moriwaki Y. (1972) Odorous compounds in water supplies: detection of geosmin from water of the southern basin of Lake Biwa (in Japanese, with English title). *Yakugaku Zasshi* **92**, 1441–1442.
- Leger L. (1910) Le gout de vase chez les poissons d'eau douce. *Trav. Lab. Piscic. Univ. Grenoble* **2**, 1–4.
- Lillard D. A. & Powers J. J. (1975) Aqueous odor thresholds of organic pollutants in industrial effluents. National Environmental Research Center, United States Environmental Protection Agency, Corvallis, Oregon, *Environmental Monitoring Series*, EPA-660/4-75-002.
- Medsker L. L., Jenkins D. & Thomas J. F. (1968) Odorous compounds in natural waters. An earthy-smelling compound associated with blue-green algae and actinomycetes. *Environ. Sci. Technol.* **2**, 461–464.
- Medsker L. L., Jenkins D., Thomas J. F. & Koch C. (1969) Odorous compounds in natural waters. 2-exo-hydroxy-2-methylbornane, the major odorous compound produced by several actinomycetes. *Environ. Sci. Technol.* **3**, 476–477.
- Middlebrooks E. J. (1965) Taste and odor control. *Water & Sewage Works*, **112** (Reference number), R122–R134.
- Murray K. E., Bannister P. A. & Buttery R. G. (1975) Geosmin, an important volatile constituent of beetroot (*Beta vulgaris*). *Chem. Ind.* **22**, 973–974.
- Parliment T. H. & Epstein M. F. (1973) Organoleptic properties of some alkyl-substituted alkoxy- and alkylthiopyrazines. *J. agric. Fd Chem.* **21**, 714–716.
- Partanen A. (1969) Oulujokisuun merialueen pilaantumien. *Suomi. Kalust.* **76**, 208–211.
- Persson P.-E. (1974) On flavour tainting of fish, with special reference to the Oulu sea area (Bothnian Bay) (in Swedish, with English summary). *Rep. natn. Board Waters. Finland* **65**, 1–262.

- Persson P.-E. (1977) Muddy/earthy off-flavours in fish (in Finnish, with English summary). *Ympäristö ja terveys* 8, 515-521.
- Persson P.-E. (1978) A preliminary note on the occurrence of off-flavours in fish in Finland (in Finnish, with English summary). Reprint from *Suom. Kalust.* 85, 120-121.
- Persson P.-E. (1979a) The source of muddy odor in bream (*Abramis brama*) from the Porvoo sea area (Gulf of Finland). *J. Fish. Res. Bd Can.* 36, 883-890.
- Persson P.-E. (1979b) Notes on muddy odour. III. Variability of sensory response to 2-methylisoborneol. *Aqua Fennica* 9, 48-52.
- Persson P.-E. (1979c) Notes on muddy odour. IV. Sensory properties of geosmin in water. *Aqua Fennica* 9, 57-56.
- Persson P.-E. & York R. K. (1978) Notes on muddy odour. I. Sensory properties and analysis of 2-methylisoborneol in water and fish. *Aqua Fennica* 8, 83-88.
- Piet G. J., Zoeteman B. C. J. & Kraayeveld A. J. A. (1972) Earthy smelling substances in surface waters of the Netherlands. *Wat. Treat. Exam.* 21, 281-286.
- Polak E., Trotier D. & Baliguet E. (1978) Odor similarities in structurally related odorants. *Chem. Senses Flav.* 3, 369-380.
- Rosen A. A., Mashni C. I. & Safferman R. S. (1970) Recent developments in the chemistry of odour in water: the cause of earthy/musty odour. *Wat. Treat. Exam.* 19, 106-114.
- Rosen A. A., Safferman R. S., Mashni C. I. & Romano A. H. (1968) Identity of odorous substance produced by *Streptomyces griseoluteus*. *Appl. Microbiol.* 16, 178-179.
- Safferman R. S., Rosen A. A., Mashni C. I. & Morris M. E. (1967) Earthy-smelling substance from a blue-green alga. *Environ. Sci. Technol.* 1, 429-430.
- Seifert R. M., Buttery R. G., Guadagni D. G., Black D. R. & Harris J. G. (1970) Synthesis of some 2-methoxy-3-alkylpyrazines with strong bell pepper-like odors. *J. agric. Fd Chem.* 18, 246-249.
- Silvey J. K. G. & Roach A. W. (1975) The taste and odor producing actinomycetes. *C.R.C. Crit. Rev. Environ. Control* 5, 233-273.
- Tabachek J. L. & Yurkowski M. (1976) Isolation and identification of blue-green algae producing muddy odor metabolites geosmin and 2-methylisoborneol in saline lakes in Manitoba. *J. Fish. Res. Bd Can.* 33, 25-35.
- Thaysen A. C. (1936) The origin of an earthy or muddy taint in fish. I. The nature and isolation of the taint. *Ann. appl. Biol.* 23, 99-104.
- Van Gemert L. J. & Nettenbreijer A. H. (1977) *Compilation of Odour Threshold Values in Air and Water*. National Institute for Water Supply, Voorburg, Netherlands, and Central Institute for Nutrition and Food Research, Zeist, Netherlands.
- Weete J. D., Blevins W. T., Wilt G. R. & Durham D. (1977) Chemical, biological and environmental factors responsible for the earthy odor in the Auburn City water supply. *Bull. agric. Expt. Sta. Ala.* 490, 1-46.
- Wood N. F. & Snoeyink V. L. (1977) 2-Methylisoborneol, improved synthesis and a quantitative gas chromatographic method for trace concentrations producing odor in water. *J. Chromat.* 132, 405-420.
- Yurkowski M. & Tabachek J. L. (1974) Identification, analysis and removal of geosmin from muddy-flavored trout. *J. Fish. Res. Bd Can.* 31, 1851-1858.
- Zoeteman B. C. J. & Piet G. J. (1973) Drinkwater is nog geen water drinken. *H₂O* 6, 174-177.

SAN FRANCISCO ESTUARY & WATERSHED

Sponsored by the Delta Science Program and the UC Davis John Muir Institute of the Environment

Ecosystem-Scale Selenium Model for the San Francisco Bay-Delta Regional Ecosystem Restoration Implementation Plan (DRERIP)

Theresa S. Presser^{1,†} and Samuel N. Luoma^{1,2}

ABSTRACT

Environmental restoration, regulatory protections, and competing interests for water are changing the balance of selenium (Se) discharges to the San Francisco Bay-Delta Estuary (Bay-Delta). The model for Se described here as part of the Delta Regional Ecosystem Restoration Implementation Plan (DRERIP) draws both from the current state of knowledge of the Bay-Delta and of environmental Se science. It is an ecosystem-scale methodology that is a conceptual and quantitative tool to (1) evaluate implications of Se contamination; (2) better understand protection for fish and aquatic-dependent wildlife; and (3) help evaluate future restoration actions. The model builds from five basic principles that determine ecological risks from Se in aquatic environments: (1) dissolved Se transformation to particulate material Se, which is partly driven by the chemical species of dissolved Se, sets dynamics at the base of the food web; (2) diet drives bioavailability of Se to animals; (3) bioaccumulation differs widely among invertebrates, but not necessarily among fish; (4) ecological risks dif-

fer among food webs and predator species; and (5) risk for each predator is driven by a combination of exposures via their specific food web and the species' inherent sensitivity to Se toxicity. Spatially and temporally matched data sets across media (i.e., water, suspended particulate material, prey, and predator) are needed for initiating modeling and for providing ecologically consistent predictions. The methodology, applied site-specifically to the Bay-Delta, includes use of (1) salinity-specific partitioning factors based on empirical estuary data to quantify the effects of dissolved speciation and phase transformation; (2) species-specific dietary biodynamics to quantify foodweb bioaccumulation; and (3) habitat use and life-cycle data for Bay-Delta predator species to illustrate exposure. Model outcomes show that the north Bay-Delta functions as an efficient biomagnifier of Se in benthic food webs, with the greatest risks to predaceous benthivores occurring under low flow conditions. Improving the characterization of ecological risks from Se in the Bay-Delta will require modernization of the Se database and continuing integration of biogeochemical, ecological, and hydrological dynamics into the model.

KEY WORDS

Selenium, biodynamics, bioaccumulation, food webs, ecotoxicology, ecology.

† Corresponding author: tpresser@usgs.gov

1 U.S. Geological Survey, 345 Middlefield Road, Menlo Park, CA 94025

2 Current affiliation: John Muir Institute of the Environment, University of California Davis, Davis, CA 95616

SAN FRANCISCO ESTUARY & WATERSHED SCIENCE

INTRODUCTION

The Delta Regional Ecosystem Restoration Implementation Plan (DRERIP) process focuses on construction of conceptual models that describe and define the relationships among the processes, habitats, species, and stressors for the Bay-Delta (DiGennaro and others 2012). The models use common elements and are designed to interconnect to achieve the goals of evaluating and informing Bay-Delta restoration actions. Selenium is recognized as an important stressor in aquatic environments because of its potency as a reproductive toxin and its ability to bioaccumulate through food webs (Chapman and others 2010; Presser and Luoma 2010a). Selenium's role is well documented in extirpation (i.e., local extinctions) of fish populations (Lemly 2002) and in occurrences of deformities of aquatic birds in affected habitats (Skorupa 1998). For Se, exposure is specific to a predator species' choice of food web and physiology, making some predators more vulnerable and, thus, more likely than others to disappear from moderately contaminated environments (Lemly 2002; Luoma and Presser 2009; Stewart and others 2004).

Concern about Se as a stressor in the Bay-Delta watershed originates from the damage to avian and fish populations that resulted when an agricultural drain to alleviate subsurface drainage conditions in the western San Joaquin Valley released Se into the Kesterson National Wildlife Refuge in the 1980s (Presser and Ohlendorf 1987). Later it was recognized that (1) some aquatic predators in the Bay-Delta were bioaccumulating sufficient Se to threaten their reproductive capabilities (SWRCB 1987, 1988, 1989, 1991) and; (2) primary Se sources included not only organic enriched sedimentary deposits in the San Joaquin Valley and elsewhere, but also their anthropogenic by-products such as oil (Cutter 1989; Presser 1994; Presser and others 2004). Proposals in 1978 and 2006 to extend an agricultural drain from the western San Joaquin Valley directly to the Bay-Delta as a way of removing Se from the valley were found both times to present substantial and broad ecological risks (e.g., USBR 1978, 2006; Presser and Luoma 2006).

Currently, Se contamination is spatially distributed from the Delta through the North Bay (Suisun Bay, Carquinez Strait, and San Pablo Bay) to the Pacific Ocean, mainly from oil-refining discharges internal to the estuary, and agricultural drainage discharges exported via the San Joaquin River. Regulatory and planning processes have intervened in the cases of both existing Se sources resulting in a decline in contamination since 1986-1992 when concentrations were maximal (SWRCB 1987, 1988, 1989, 1991; Presser and Luoma 2006; USBR 1995, 2001, 2009). However, the North Bay, the Delta, and segments of the San Joaquin River and some of its tributaries and marshes remain designated as impaired by Se (SWRCB 2011). More recently, the State initiated a Se Total Maximum Daily Load (TMDL) process to target both agricultural and oil refinery sources of Se (SFBWRQCB 2007, 2011) in coordination with development and implementation of site-specific water quality Se criteria for the protection of fish and wildlife by the U.S. Environmental Protection Agency (USEPA 2011a). The presence of a major oil-refining industry in the North Bay, and the substantial accumulated reservoir of Se in the soils and aquifers of the western San Joaquin Valley suggest that the potential for ecological risk from Se within the Bay-Delta watershed will continue into the foreseeable future as Se management and mitigation efforts take place (Presser and Luoma 2006; Presser and Schwarzbach 2008; USBR 2008; Appendix A.1).

Historic and more recent data show that certain predator species are considered most at risk from Se in the Bay-Delta (e.g., white and green sturgeon, scoter, scaup) because of high exposures obtained when they consume the estuary's dominant bivalve, *Corbula amurensis*, an efficient bioaccumulator of this metalloid (Stewart and others 2004; Presser and Luoma 2006). The latest available surveys of Se concentrations in *C. amurensis* and white sturgeon (*Acipenser transmontanus*) that were feeding (based upon isotopic evidence) in Carquinez Strait, Suisun Bay, and San Pablo Bay (Stewart and others 2004; Linares and others 2004; Kleckner and others 2010; Presser and Luoma 2010b; SFEI 2009) continue to show concentrations exceeding U.S. Fish and Wildlife Service (USFWS) dietary and tissue toxicity guide-

MARCH 2013

ines (Skorupa and others 2004; Presser and Luoma 2010b). Sturgeon contain higher concentrations of Se than any other fish species, reflecting their position as a top benthic predator (Stewart and others 2004). Surveys of surf scoter (*Melanitta perspicillata*) and greater scaup (*Aythya marila*) that feed voraciously on *C. amurensis* as they overwinter in Suisun Bay (SFEI 2005; De La Cruz and others 2008; De La Cruz 2010; Presser and Luoma 2010b) show Se has bioaccumulated to levels in muscle and liver tissue that may affect their ability to successfully migrate and breed (Heinz 1996; USDOT 1998; Ohlendorf and Heinz 2011).

Endangered Species Act requirements led to a number of species being determined as jeopardized by Se in the Bay-Delta under a proposed chronic aquatic life Se criterion of $5 \mu\text{g L}^{-1}$ (USFWS and NOAA Fisheries 2000), including delta smelt (*Hypomesus transpacificus*); longfin smelt (*Spirinchus thaleichthys*); Sacramento splittail (*Pogonichthys macrolepidotus*); Sacramento perch (*Archoplites interruptus*); tidewater goby (*Eucyclogobius newberryi*); green sturgeon (*Acipenser medirostris*) and its surrogate white sturgeon (*Acipenser transmontanus*); steelhead trout (*Oncorhynchus mykiss*); Chinook salmon (*Oncorhynchus tshawytscha*); California clapper rail (*Rallus longirostris obsoletus*); California least tern (*Sterna antillarum browni*); bald eagle (*Haliaeetus leucocephalus*); California brown pelican (*Pelecanus occidentalis californicus*); marbled murrelet (*Brachyramphus marmoratus*); and giant garter snake (*Thamnophis gigas*). Recent analysis by the USFWS (2008a) of 45 species assumed the species most at risk depended on benthic food webs: greater scaup; lesser scaup (*Aythya affinis*); white-winged scoter (*Melanitta fusca*); surf scoter; black scoter (*Melanitta nigra*); California clapper rail; Sacramento splittail; green sturgeon; and white sturgeon. Not enough species-specific information is currently available for consideration of Se exposures for the giant garter snake, an endangered aquatic predator (USFWS 2006, 2009); the Dungeness crab (*Cancer magister*), an invertebrate that consumes *C. amurensis* (Stewart and others 2004); or for species that are within the Dungeness-crab food webs.

Human health advisories currently are posted for the Bay-Delta for the consumption of scoter, greater scaup, and lesser scaup based on elevated Se concentrations in their muscle and liver tissue (CDFG 2012, 2013). Selenium was found to be below the level of human health concern for consumption of edible tissue in certain species of fish, including white sturgeon, from the estuary (OEHHA 2011). White sturgeon contained the highest levels of Se among species of fish surveyed. Some individual white sturgeon sampled from North Bay locations had Se concentrations that exceeded Se advisory levels, based on specific consumption rates (see later detailed discussion under "Human Health" on page 23). Additionally, white sturgeon recreational fishing is limited, based on a decreasing species population (CDFG 2012).

It was recently suggested that the traditional regulatory approach to managing Se contamination is deeply flawed (Reiley and others 2003; Luoma and Presser 2009; Chapman and others 2010), and that a new conceptual model of the processes that control its toxicity is needed for regulatory purposes, especially in estuarine environments like the Bay-Delta. In recognition of the issues with the traditional approach to deriving a criterion for Se, the USEPA is leading a cooperative effort to develop site-specific fish and wildlife Se criteria for habitats affected by Se in California. Specifically for the Bay-Delta, the effort includes protection of Federally listed species and designated critical habitat (USFWS and NOAA Fisheries 2000; USEPA 2011a). Development of Se criteria for the Bay-Delta is proceeding first in this effort because the estuary is considered a sensitive hydrologic system and habitat in terms of Se and it was thought that protection here would elicit regulatory compliance upstream (USEPA 2011a). On the broader scale, Se is considered a general stressor of the estuary, and a constituent that should be analyzed as part of management and restoration planning and implementation (USEPA 2011b; NRC 2010, 2011, 2012).

The cooperative regulatory effort specifically recognizes that the new conceptual model must consider (1) the inaccuracies of deriving toxicity from waterborne Se concentrations; (2) the bioaccumulative nature of Se in aquatic systems; (3) Se's long-term

SAN FRANCISCO ESTUARY & WATERSHED SCIENCE

persistence in aquatic sediments and food webs; and (4) the importance of dietary pathways in determining toxicity (USEPA 1992, 2000a; USFWS and NOAA Fisheries 2000; Luoma and Presser 2009; Presser and Luoma 2006, 2010a, 2010b). Revisions by USEPA also are occurring at the national level to incorporate into the basis for regulation recent advances in the environmental science of Se. For example, a fish tissue Se criterion and implementation plan are being proposed to better integrate dietary exposure pathways into regulatory frameworks, and ensure an adequate link to toxicity (USEPA 2004, 2011b). During this transitional period when species may be jeopardized and while Se criteria are being revised, USEPA has applied the national chronic freshwater Se criterion of $5\mu\text{g L}^{-1}$ to the estuary (USEPA 1992, 2000a).

We present here an ecosystem-scale Se conceptual model for the Bay-Delta that addresses the needs of both the DRERIP process and the USEPA. Quantitative applications of the model are also possible. Quantification provides an opportunity to evaluate site-specific Se risks under different circumstances, using field data combined with a systematic quantification of each of the influential processes that link source inputs of Se to toxicity. The methodology is presented in terms of specified DRERIP components (i.e., drivers, linkages, and outcomes). As an example of how quantitative applications can be used, we calculate the dissolved ambient Se concentrations that would result in compliance with a chosen fish or bird tissue guideline under different assumptions or environmental conditions. Uncertainties and model sensitivities are illustrated by comparing outcomes of different exposure scenarios. The scenario approach could facilitate the model's use by decision-makers for quantitative evaluation of restoration alternatives for ecosystem management and protection.

MODEL OVERVIEW

The DRERIP Ecosystem-Scale Selenium Model for the Bay-Delta (Figure 1) has five interconnected modules that depict drivers (sources and hydrology), linkages (ecosystem-scale processes), concentration outcomes

(Se concentrations in water, particulates, and organisms), and food web exposure outcomes (effects on fish, wildlife, and human health). Model outcomes in Figure 1 are further refined to critical choices for modeling and species-specific risk scenarios for the Bay-Delta. Together the five modules consider the essential aspects of environmental Se exposure: biogeochemistry, food web transfer, and effects. They also take into account the estuary's ecology and hydrology as well as the functional ecology, physiology and ecotoxicology of the most vulnerable predator species. The modules define relationships that are important to conceptualizing and quantifying how Se is processed from water through diet to prey and predators, and the resulting effect on components of the food web. Thus, the DRERIP Ecosystem-Scale Selenium Model combines fundamental knowledge of Se behavior in ecosystems (Se drivers, linkages, and outcomes) with site-specific knowledge of the Bay-Delta (Bay-Delta drivers, linkages, and outcomes) to define site-specific Se risk (Figure 1).

The DRERIP Se submodels provide details for

- Sources and Hydrology (submodel A, Figure 2);
- Ecosystem-Scale Se Modeling (submodel B, Figure 3);
- Exposure: Food Webs, Seasonal Cycles, Habitat Use (submodels C, D; Figures 4, 5);
- Fish and Wildlife Health: Ecotoxicology and Effects (submodels E, F; Figures 6, 7); and
- Human Health (submodel G, Figure 8).

A human health pathway is designated, but emphasis here is on Se pathways to fish and wildlife health. The North Bay and the Delta are emphasized because the important Se sources have the potential to most affect those habitats and ecosystems (submodel A, Figure 2).

The quantitative DRERIP Ecosystem-Scale Selenium Model is based upon concepts and parameters developed elsewhere for a wide variety of aquatic systems and their food webs (submodel B, Figure 3; submodel E, Figure 6) (Luoma and Rainbow 2005; Luoma and Presser 2009; Chapman and others 2010; Presser and Luoma 2010a). To quantitatively apply the rela-

STATEMENT AVAILABLE FOR RELEASE – THURSDAY, JULY 18, 2013

Federal Agency Comments Received on the Bay Delta Conservation Plan (BDCP) Second Administrative Draft Environmental Impact Report/Environmental Impact Statement (EIR/EIS)

The federal lead agencies for the BDCP EIR/EIS, the U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, and National Marine Fisheries Service, provided their state partner, the California Department of Water Resources (DWR) and the environmental consultants with comment memos on the Consultant Second Administrative Draft EIR/EIS (Admin Draft), released on May 10, 2013. These comments are offered to improve content and readability of the Admin Draft. State and federal lead agencies for the BDCP EIR/EIS are confident that the issues identified in the comment memos will be resolved in the ongoing development of the BDCP and environmental review process, including the public review draft EIR/EIS scheduled for release this October and the final EIR/EIS.

"These comments are intended to be helpful and underscore the good collaboration that exists in this complex planning process," said Will Stelle, NMFS West Coast Salmon Coordinator. "We anticipate that, like the issues that are currently being discussed in relation to the draft habitat conservation plan, these issues can be dealt with in a manner that is acceptable to both the state and federal agencies involved."

"Securing California's foundational water supply for two-thirds of the state against the certainty of sea level rise and earthquakes remains a top priority of the Brown administration," said Natural Resources Agency Deputy Secretary Jerry Meral. "In context, it is important to remember that regulatory agencies by their nature do not give out 'gold stars' for work, but roadmaps for improvement. We will continue to follow that map, because our water security relies on it. After meeting for two days with the federal and state agencies working on this project, we are confident that we can produce a good draft plan and EIS for the public to review, and that all the issues raised in the comments can be successfully resolved in the coming months."

The comment memos outline areas in the Admin Draft that may need further consideration. The release of this information is part of an ongoing and unprecedented effort to promote an open and transparent environmental review process for BDCP, a habitat conservation plan under state and federal endangered species laws that is designed to improve habitat in the Bay-Delta ecosystem and improve water supply reliability for 25 million Californians.

The Admin Draft reflects the significant downsizing of the proposed conveyance project that occurred in 2012 in direct response to federal and state wildlife agency comments. That downsizing includes a reduction in the number of intakes from five to three, a reduction in the maximum diversion capacity from 15,000 to 9,000 cubic feet per second, and a change to gravity-flow tunnels that would not require pressurization and additional pumping plants to move water. The environmental documents also include additional commitments that provide mechanisms to address water quality concerns raised by local water districts. In response to comments from federal agencies, the draft environmental documents will be revised to include

additional modeling that further refines the analysis of sea level rise and climate change effects. The public draft EIR/EIS will reflect that work.

"We have made significant progress in improving the overall integrity and accuracy of these draft environmental documents in the last year," said DWR Director Mark Cowin. "Clearly, there is more work to be done, and our team has already taken up the challenge to improve and enhance these documents in order to meet the ambitious deadline agreed to by the Governor and Secretary of the Interior."

The Admin Draft reflects improvements in analysis to show geographic-specific impacts, additional mitigation measures, and environmental commitments that extend beyond the scope of required mitigation actions under CEQA. This Admin Draft will undergo further necessary revisions, based on comments received to date, as part of the ongoing development of the Public Review Draft EIR/EIS scheduled to be released in October 2013. State and federal lead agencies will open a formal public comment period and, as part of completing the process, respond in writing to all public comments that are received.

In addition to the federal lead agency comments, BDCP is also making available comments provided by federal cooperating agencies – the U.S. Environmental Protection Agency and the U.S. Army Corps of Engineers. Numerous state and local agencies are recognized as cooperating agencies under NEPA and responsible agencies under CEQA and have been actively involved in providing initial comments on the Admin Draft.

The EIR/EIS documents are available for review at www.baydeltaconservationplan.com.

Reclamation's List of Key BDCP Adm. Draft EIR/EIS Issues

July 5, 2013

Clarification Added: July 16, 2013

- The language and content of the BDCP Adm. Draft EIR/EIS are advocating for the project.
 - From a NEPA standpoint, the language should be neutral to meet the regulatory requirement of a “full and fair discussion of significant environmental impacts....” 42 CFR 1502.1.
 - Global review to adjust such language should be made.
- The identification of adverse and beneficial impacts is very subjective and appears to be based on a misreading of NEPA regulations.
 - NEPA regulations require identification of adverse impacts that cannot be avoided should the proposal be implemented and means to mitigate adverse impacts. Otherwise, all effects should be identified as absolutes rather than as subjective judgments as to whether an effect is beneficial or adverse. These effects and their significance should be explained considering both context and intensity.
 - In many areas, the document contains a CEQA analysis to which a few NEPA terms have been added to call it a NEPA analysis. For instance, in at least some chapters the consultant has created criteria, analogous to significance criteria under CEQA, for determining whether an impact is adverse under NEPA. This method of analysis is not consistent with NEPA.
- Reclamation is listed as a Lead Agency, but the whole of Reclamation's actions is not analyzed (i.e. Delta vs whole CVP).
 - Document scope not inclusive of all CVP actions
 - The whole of Reclamation actions in the Delta are analyzed, but not Reclamation's actions outside the Delta.
 - Analysis of upstream affects may not be sufficient to serve as NEPA compliance for Reclamation to accept BiOp depending on the outcome of pending 9th circuit appeal filed by NRDC specific to NEPA analysis of RPA prior to implementation by Action Agency.
 - The EIR/EIS should clearly and fully “finish the thoughts” regarding the Reclamation actions and the issuance of ITPs by including these topics directly in the discussion of alternatives and by stating that the multiple decision documents will ultimately result from the EIR/EIS.

Clarification: The current BDCP analysis assumes no operational impacts to upstream reservoir operations. Reclamation will continue to evaluate resulting upstream operational changes as necessary within the new operating regime under BDCP. If additional effects, outside of what has already been evaluated are identified, Reclamation will analyze those under a supplemental NEPA

WORKING DRAFT – FOR DISCUSSION PURPOSES

process prior to accepting and implementing the BDCP Biological Opinion. Reclamation does not believe this will affect the BDCP schedule.

- The document is vague about the relationship between the various agency actions that compose or relate to the BDCP, including how these actions will be sequenced and the time/manner of environmental analysis for each.
 - Some of the federal actions are expected to be future considerations/decisions and will need additional NEPA analysis.
 - It would be helpful for the document to summarize how, in time and in relationship to one another, all of the federal and state decisions are expected to occur.
- Ongoing Modeling and Operational refinements associated with CM1 need to be incorporated in the draft EIR/EIS as additional information becomes available.
 - Chapter 30 distinguishes between operational scenarios by indicating whether Fall X2 is included or excluded and little else. These operational scenarios vary by more than the Fall X2 and should be described.
- Need to determine how to address potential COA implications associated with implementation of CM1 operating criteria.
 - The analysis should be more explicit about the assumptions made in terms of COA implementation, as well as other assumptions regarding the water to be made available to the CVP and SWP.
 - Chapter 5 does not attempt to analyze affects to water supplies other than CVP and SWP supplies. There is a cursory statement in the beginning that changes to operation of the CVP and SWP cannot affect senior water rights holders and that none of those supplies would be affected. It would be helpful to have more information to support that conclusion or to explain why no other supplies are addressed. There is also no discussion of other water users who might utilize state or federal facilities through Warren Act contracts or other arrangements that have the potential to be affected by a change in facilities or operations.
 - The assumptions regarding the allocation of water between CVP and SWP users are not explained. There seems to be an assumption that if CVP deliveries increase north of the Delta that it will automatically mean a reduction in availability of CVP water south of the Delta. Not sure that this is consistent with COA.
 - At a minimum, the following should be added to Chapter 5 and Appendix 5A addressing the COA issue: *"The changes in facilities and operating criteria should trigger a review of the agreement. A review may result in changes in sharing of water supplies and responsibilities. Although the changes are unlikely to affect operations of facilities in the Delta, the future shares of SWP/CVP water supplies may differ from the quantities shown in the modeling results."*

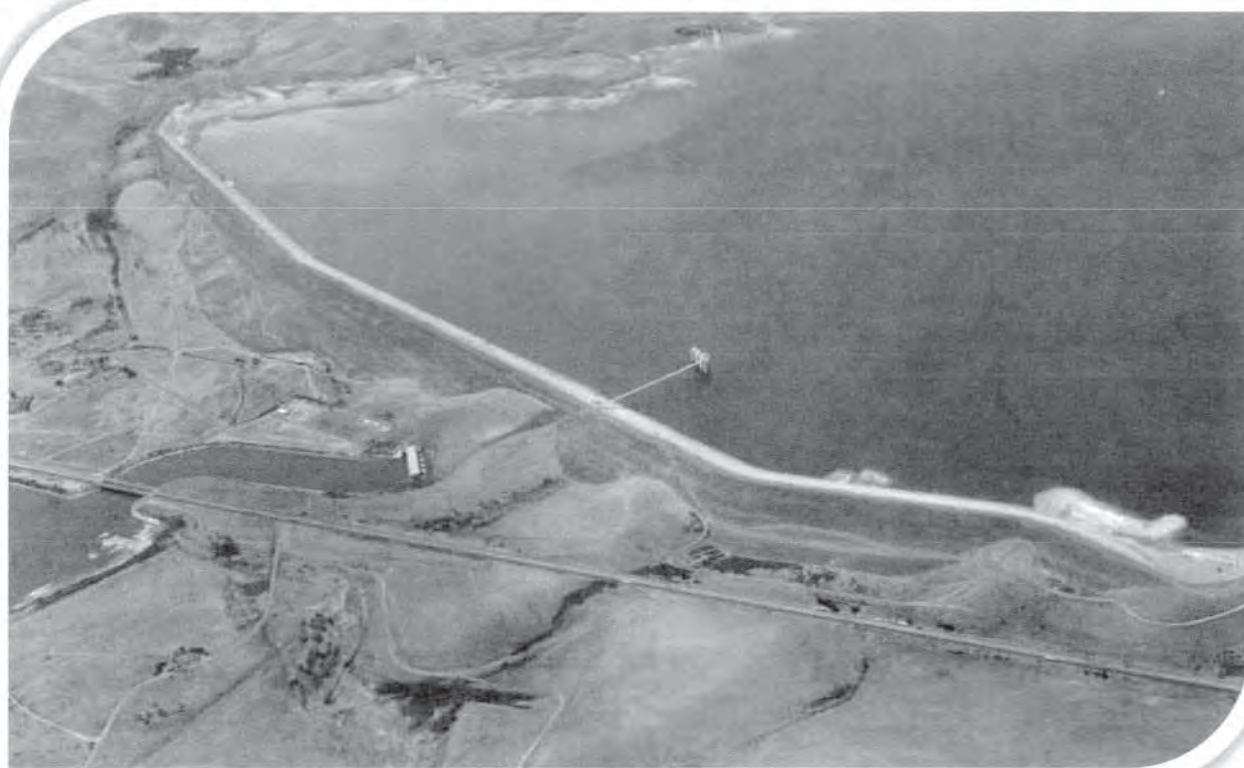
- Changes in operation of the CVP in the near-term, prior to new facilities being in place and operational, need to be clarified.
 - Reclamation's understanding has been that the existing/remanded BOs would govern operations until new facilities are operational.
 - The statement below requires clarification. It addresses changes in operation of the CVP in the near-term, prior to new facilities being in place and operational. On the bottom of page 148 in Chapter 3 it says - *"The existing CVP facilities described in this section would be operated under both the BDCP near-term and long-term implementation, but with differing operating criteria following completion of new facilities. The BDCP near- and long-term operational criteria and adaptive operational range are described in Section 3.6.4.2, and include descriptions of operations of CVP facilities in the Plan Area."*
 - Is there some expectation that we would change operation of the CVP/SWP prior to operation of the new facilities in accordance with that outlined in Section 3.6.4.2?
 - Perhaps it's just outdated language? If so, we ask that any reference to near-term operations be deleted from the EIR/EIS.
 - Text in the BDCP and EIR/EIS documents should make it clear that the existing/remanded BOs will govern operations until new BDCP facilities are in place.

RECLAMATION

Managing Water in the West

San Luis Reservoir Expansion Draft Appraisal Report

Central Valley Project, California
Mid-Pacific Region



U.S. Department of the Interior
Bureau of Reclamation
Mid-Pacific Region - Planning Division

December 2013

DRAFT



U.S. Department of the Interior
Bureau of Reclamation
Mid-Pacific Region - Planning Division

December 2013

Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

San Luis Reservoir Expansion Draft Appraisal Report

**Central Valley Project, California
Mid-Pacific Region**



**U.S. Department of the Interior
Bureau of Reclamation
Mid-Pacific Region - Planning Division**

Table of Contents

1.0	EXECUTIVE SUMMARY	1
2.0	INTRODUCTION.....	4
2.1	Purpose of the Appraisal Study	4
2.2	Need for the Appraisal Study	5
2.3	Authorization for Appraisal Study	5
2.4	Study Area.....	6
3.0	PROBLEMS AND OPPORTUNITIES	8
3.1	Problems.....	8
3.2	Opportunities.....	10
3.3	Objectives.....	11
3.4	Constraints.....	11
4.0	EXISTING CONDITIONS	13
4.1	Facilities	13
4.1.1	Dam Embankment	13
4.1.2	Gianelli Pumping-Generating Plant.....	15
4.1.3	Intake Towers / Trashrack Structures	15
4.1.4	Trashrack Structure Access Bridge.....	17
4.1.5	Spillway	17
4.2	Reservoir Area-Capacity	18
4.3	Related Projects.....	19
4.4	Previous Studies	22
4.5	Influencing Contracts, Agreements, and Conditions	24
5.0	MANAGEMENT MEASURES	27
5.1	Non-Structural Measures.....	27
5.2	Structural Measures.....	28
5.3	Alternatives	30
5.3.1	No Action Alternative.....	30
5.3.2	Conceptual Dam Raise Alternative.....	30

6.0	CONSIDERATIONS FOR STRUCTURAL MODIFICATIONS.....	32
6.1	Intake Towers/Trashrack Structures.....	32
6.2	Trashrack Structure Access Bridge.....	32
6.3	Spillway.....	32
7.0	WATER OPERATIONS AND BENEFITS FORECAST.....	34
7.1	Existing Operations.....	34
7.2	Water Supply Forecast.....	35
7.2.1	Method 1: Spreadsheet Analysis of CalSim-II Results.....	35
7.2.2	Method 2: CalLite Modeling Analysis.....	37
7.3	Summary of Results.....	39
8.0	ENVIRONMENTAL.....	40
9.0	COST ESTIMATES.....	41
10.0	FINDINGS AND RECOMMENDATIONS.....	43
10.1	Findings.....	43
10.2	Recommendations.....	44
11.0	REFERENCES.....	45

ATTACHMENT A

B.F. Sisk Dam Increased Storage Alternatives, Appraisal Level Study: Technical Memorandum
No. VB-86-68313-25

ATTACHMENT B

Sisk Enlargement Appraisal Level Modeling Analysis

Figures

Figure 1. Major facilities of the San Luis Unit and the appraisal study area.....	7
Figure 2. Typical Section of B.F. Sisk Dam	14
Figure 3. Close-up of B.F. Sisk Dam and Gianelli Pumping-Generating Plant	14
Figure 4. Outlet works intake towers and access bridge.....	16
Figure 5. Overview of B.F. Sisk inlet and outlet structures.....	17
Figure 6. Area-Capacity curves for San Luis Reservoir and O'Neill Forebay	18
Figure 7. Locations of CALFED surface storage investigations relative to the Sisk study area.	23
Figure 8. Typical section of the conceptual modification alternative	31
Figure 9. Approximate limits of spillway demolition.....	33
Figure 10. A 10 year plot of long-term San Luis reservoir volume.....	34

Tables

Table 1. Maximum additional annual export opportunities by water year type *	36
Table 2. Additional export opportunities stored by various capacity increases*	37
Table 3. Average Annual Additional Deliveries of CVP and SWP (TAF/yr)*	38
Table 4. Change in North-of-Delta Average End of September Storage (TAF)	38
Table 5. Summary of maximum and minimum estimated water supply benefits	39
Table 6. Summary of appraisal level field cost estimates.....	42

Acronyms and Abbreviations

AF	acre-feet
BA	Biological Assessment
BDCP	Bay-Delta Conservation Plan
BO	Biological Opinion
CALFED	CALFED Bay-Delta Program
CA	California Aqueduct
CAS	Corrective Action Study
CEQA	California Environmental Quality Act
COA	CVP/SWP Coordinated Operations Agreement
cfs	cubic-feet per second (ft ³ /s)
CVOO	Reclamation Central Valley Operations Office
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
D-1641	SWRCB Water Right Decision 1641
DMC	Delta-Mendota Canal
DWR	California Department of Water Resources
Delta	Sacramento-San Joaquin Delta
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
ESA	Endangered Species Act
ft ³ /s	cubic feet per second
JPOD	Joint Point of Diversion
M&I	Municipal and Industrial
MAF	million acre-feet
mo	month
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
OCAP	Operations Criteria and Plan
OMR	Old and Middle River
Reclamation	The U.S. Bureau of Reclamation
RPA	reasonable and prudent alternatives
RWS	reservoir water surface
SLLPIP	San Luis Low Point Improvement Project
SWP	State Water Project
SWRCB	State Water Resource Control Board
TAF	thousand acre-feet
TM	Technical Memorandum
TSC	Reclamation's Technical Service Center
USFWS	U.S. Fish and Wildlife
yr	Year

1.0 EXECUTIVE SUMMARY

The Bureau of Reclamation (Reclamation) developed this Appraisal Report to document studies to increase the storage capacity of San Luis Reservoir (behind B.F. Sisk Dam) to improve the reliability of Central Valley Project (CVP) and State Water Project (SWP) water supplies dependent upon San Luis Reservoir. Seismic risks under the dam and in the Delta, regulatory constraints to operating Delta export facilities, algae blooms at low water levels, and future climate change have and will reduce the reliability of CVP/SWP deliveries dependent upon the San Luis Reservoir.

Reclamation initiated feasibility studies of delivery reliability risks associated with algal blooms and low reservoir levels in 2001 with the San Luis Low Point Improvement Project (SLLPIP) feasibility study, authorized by P.L. 108-361. The SLLPIP Initial Alternatives Information Report identified raising B.F. Sisk (Sisk) Dam as one alternative to the low point problem; however, the alternative was eliminated from study after the Plan Formulation Report (PFR) because more cost-effective solutions seemed available at that time.

In 2006, as a response to studies that determined B.F. Sisk dam poses a potential risk of seismic failure, Reclamation also initiated a Safety of Dams Corrective Action Study (CAS) to determine a course of action to reduce the seismic risks at the dam. Alternatives being evaluated in the CAS include raising the dam and adding abutments, as well as restricting the water level in San Luis Reservoir.

Since then, Delta export facilities have been further restricted to protect threatened and endangered species in the Central Valley, and the State of California has initiated the Bay-Delta Conservation Plan to address the delivery reliability issues related to water exports from the Delta. This effort may or may not fully address delivery reliability issues related to San Luis Reservoir, and additional storage in San Luis Reservoir may be needed to further restore delivery reliability and system flexibility.

Modifications to the dam embankment and dike, spillway, intake towers, and access-bridge would be needed to increase storage capacity within San Luis Reservoir and reduce identified dam safety risks. These modifications have been found to be technically feasible to construct. Attachment A to this Report contains a series of technical memoranda which provided the basis for appraisal level conceptual designs, estimated field costs, and other considerations of the requirements to raise B.F. Sisk Dam which are presented in this report.

In order to generate appraisal level cost estimates for this study, a conceptual dam raise alternative was formulated that considered co-equal objectives of increasing storage and mitigating dam safety risks, while also minimizing impacts to existing facilities. The conceptual

alternative consists of a raise of the reservoir water surface (RWS) by 10 feet and a corresponding raise of the dam crest by 20 feet, increasing reservoir capacity by approximately 130 TAF. This conceptual design included excavation of weaker foundation materials and addition of significant downstream stability berms in several areas around the dam embankment.

Total field costs were estimated to be \$360 million to construct the conceptual design. The excavation and stability berms required for reducing dam safety risks account for approximately 67% of total field costs. Costs of design, design support, construction support and construction support activities are not included in the estimated field cost. The field cost estimates for this study do include estimates for mobilization, design and construction contingencies, and allowance for procurement strategies.

The maximum estimated benefit of increasing the capacity of San Luis Reservoir by 130 TAF (10 foot increase in the water surface elevation), under existing operations and regulations, is 43 TAF of additional average annual Delta exports. Additional studies indicate that, under current operations and regulations, benefits to CVP and SWP water supply and deliveries could potentially be realized with reservoir capacity increases up to 400 TAF (~30-foot RWS raise). For example, a 400 TAF reservoir capacity increase could produce approximately 71 TAF of additional average annual Delta exports and deliveries under current operations and regulations. Based on the results of this report, additional in-depth studies exploring the opportunities for enlarging B.F. Sisk Dam to increase the capacity of San Luis Reservoir as a part of the San Luis Low Point Feasibility Study are warranted.

Further studies would be developed in coordination with Reclamation's Dam Safety Office, the State Department of Water Resources, the Santa Clara Valley Water District, and the San Luis & Delta-Mendota Water Authority, and other entities to ensure development of a feasible solution to the several risks to CVP and SWP water delivery reliability.

Based on the findings of this report, recommendations for further studies include:

- 1) Restore one or more San Luis Reservoir expansion alternatives to the San Luis Low Point Feasibility Studies to determine:
 - a) Actions needed to correct identified dam safety risks
 - b) Technical, environmental, economic, and financial feasibility of increasing south-of-Delta surface water storage capacity under a wide range of future conditions, including climate change and changes in Delta export and conveyance capacity
- 2) Address the following topics during the feasibility study process:
 - a) Refine the area-capacity calculations for an expanded San Luis Reservoir

- b) Consider the need to upgrade the Gianelli pumping plant depending on the height of capacity increasing alternatives analyzed
 - c) Opportunities to enhance recreation in the reservoir
 - d) Upgrade/improve operational representation of San Luis Reservoir in the CALSIM-II and CalLite models
 - e) Consider carryover operations with a larger reservoir to improve dry year delivery benefits
 - f) Complete a constructability evaluation to provide a detailed analysis of possible construction phasing to reduce impacts to CVP and SWP operations during construction
 - g) Complete all necessary updates to geotechnical data and models
 - h) Evaluate operational changes for sharing Delta exports and export opportunities
- 3) Manage land uses within the potentially affected areas to avoid technical and logistical conflicts that may increase the cost of the dam safety and expansion projects
- 4) Develop a cost-share agreement with non-federal partners to fund the feasibility and environmental studies.

50% Forecast

Stages

State End of the Month Storage/Elevation (TAF/Feet)

		May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Trinity	1281	1189	1061	877	721	658	607	601	640	703	814	934	1044
	Elev.	2275	2262	2241	2220	2211	2203	2202	2208	2218	2233	2248	2260
Whiskeytown	238	238	238	238	238	230	230	225	206	206	206	206	238
	Elev.	1209	1209	1209	1209	1207	1207	1205	1199	1199	1199	1199	1209
Shasta	2409	2145	1833	1522	1276	1087	1107	1231	1433	1846	2415	3056	3522
	Elev.	966	947	927	909	893	895	905	921	948	980	1010	1030
Folsom	547	528	420	341	287	277	292	316	369	461	558	655	807
	Elev.	420	406	394	385	383	386	390	398	411	424	435	450
New Melones	917	774	676	575	486	408	398	417	443	478	544	620	685
	Elev.	908	892	873	855	837	834	839	845	853	867	882	893
San Luis	569	476	341	181	77	51	97	190	389	562	696	774	738
	Elev.	436	407	377	351	364	391	432	470	501	522	537	533
Total		5350	4569	3735	3084	2711	2731	2982	3479	4255	5233	6244	7034

State End of the Month Reservoir Storage (TAF)

Oroville	
	Elev.
San Luis	
Total San Luis (TAF)	

Monthly River Releases (TAF/cfs)

Trinity	TAF	92	47	28	28	27	23	18	18	18	17	18	36
	cfs	1,498	783	450	450	450	373	300	300	300	300	300	600
Clear Creek	TAF	12	9	7	7	9	12	12	12	12	11	12	11
	cfs	190	150	120	120	150	200	200	200	200	200	200	190
Sacramento	TAF	489	565	619	501	357	246	193	200	200	194	200	178
	cfs	7955	9500	10071	8143	6000	4000	3250	3250	3250	3500	3250	3000
American	TAF	114	161	121	97	48	64	68	61	61	167	215	274
	cfs	1849	2714	1975	1570	805	1039	1139	1000	1000	3000	3500	4600
Stanislaus	TAF	76	31	29	17	14	35	12	12	13	12	12	30
	cfs	1235	516	473	277	240	577	200	200	213	214	200	505
Trinity	TAF												
	cfs												

Trinity Diversions (TAF)

	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Carr PP	33	92	159	128	35	40	19	0	3	2	10	62
Spring Crk. PP	35	89	152	120	34	30	19	23	25	35	35	33

Delta Summary (TAF)

	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Tracy	61	45	45	45	60	150	118	225	200	150	150	48
USBR Banks	0	0	0	0	0	0	0	0	0	0	0	0
Contra Costa	6.35	4.9	5.55	6.35	7	8.4	9.2	9.15	7	7	6.35	6.35
Total USBR	68	50	51	51	67	158	127	234	207	157	156	54
State Export												
Total Export	80	95	96	96	216	350	410	459	407	307	306	96
COA Balance	-207	-179	-214	-216	-123	-105	0	0	0	0	0	0

Old/Middle R. std.												
Old/Middle R. calc.	-892	-1,495	-1,486	-1,599	-3,179	-4,214	-5,272	-5,731	-5,014	-3,949	-3,547	-927

Computed DOI	4002	4001	2993	2993	3009	3497	3496	7255	12802	20874	20887	13364
Excess Outflow	0	0	0	0	0	0	0	3758	8296	9473	9484	6640
% Export/Inflow	19%	19%	18%	19%	39%	53%	61%	50%	35%	21%	19%	10%
% Export/Inflow std.	35%	35%	65%	65%	65%	65%	65%	65%	65%	35%	35%	35%

Hydrology

Water Year Inflow (TAF)	Trinity	Shasta	Folsom	New Melones
Year to Date + Forecasted	380	2,744	976	339
% of mean	31%	50%	36%	32%

CVP actual operations do not follow any forecasted operation or outlook; actual operations are based on real-time conditions.

Operational forecasts or outlooks represent general system-wide dynamics and do not necessarily address specific watershed/tributary details.

Releases or export values represent monthly averages.

Operations are updated monthly as new hydrology information is made available December through May.

**AGREEMENT
BETWEEN
THE UNITED STATES OF AMERICA
AND
THE STATE OF CALIFORNIA
FOR
COORDINATED OPERATION
OF THE
CENTRAL VALLEY PROJECT
AND THE
STATE WATER PROJECT**



UNITED STATES OF AMERICA
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CENTRAL VALLEY PROJECT CALIFORNIA



STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
STATE WATER PROJECT

AGREEMENT BETWEEN
 THE UNITED STATES OF AMERICA
 AND
 THE DEPARTMENT OF WATER RESOURCES OF
 THE STATE OF CALIFORNIA
 FOR COORDINATED OPERATION OF THE
 CENTRAL VALLEY PROJECT AND THE STATE WATER PROJECT

Table of Contents

<u>Article</u>	<u>Title</u>	<u>Page</u>
1	Preamble	1
2	Explanatory Recitals	1
3	Definitions	4
4	Term of Agreement	7
5	Facilities	7
6	Coordination of Operations	8
7	Forecasting	12
8	Water Measurement Responsibilities	13
9	Reduction in United States and State Exports	13
10	Exchanges, Conveyance, and Purchases of Water Supply	14
11	Delta Standards	20
12	Monitoring	22
13	Records	22
14	Periodic Review	23
15	Relation to Agreement of May 16, 1960	25
16	New Facilities	25

Table of Contents (Continued)

<u>Article</u>	<u>Title</u>	<u>Page</u>
17	Project Service Areas	26
18	Third Party Rights Unaffected	26
19	Effect of Waiver of Breach	26
20	Equal Employment Opportunities	26
21	Contingent Provisions	29
22	Officials Not to Benefit	29
	Signature Clause	30

Exhibits

A	Standards for the Sacramento-San Joaquin Delta
B-1	Central Valley Project and State Water Project Annual Supplies
B-2	Central Valley Project and State Water Project Full Development Annual Supplies
C	Monitoring Locations
D	Exchange Procedure to Provide D-1485 Condition 3 Replacement Water (Article 10b of COA)
E	Water Shortage and Apportionment

AGREEMENT BETWEEN
 THE UNITED STATES OF AMERICA
 AND
 THE DEPARTMENT OF WATER RESOURCES OF
 THE STATE OF CALIFORNIA
 FOR COORDINATED OPERATION OF THE
 CENTRAL VALLEY PROJECT AND THE STATE WATER PROJECT

1. THIS AGREEMENT, made the _____
 day of _____, 198__, pursuant to the Act of
 Congress approved October 27, 1986, P.L. 99-546, and pursuant
 to the California Central Valley Project Act, which is Part 3,
 Division 6 (commencing at Section 11100) of the California
 Water Code, and the California Water Resources Development
 Bond Act, Chapter 8, Part 6, Division 6 (commencing at
 Section 12930) of the California Water Code, between THE
 UNITED STATES OF AMERICA, herein called the United States,
 acting through the Bureau of Reclamation, Department of the
 Interior, represented by the Contracting Officer executing
 this agreement, and THE DEPARTMENT OF WATER RESOURCES OF THE
 STATE OF CALIFORNIA, herein called the State, represented by
 the Director of Water Resources.

EXPLANATORY RECITALS

2. The United States has under construction and
 is operating the Central Valley Project, California, for the

development, conservation, control, and utilization of water resources in California.

The State has under construction and is operating initial facilities of the State Water Resources Development System, herein called the State Water Project, for the development, conservation, control, and utilization of water resources in California.

The United States and the State entered into an agreement on May 16, 1960, Article 16 of which recognizes the need for criteria for the coordinated operation of the Central Valley Project and the State Water Project.

Certain basic assumptions of that agreement require modification in light of subsequent developments and changes in the two projects.

The United States and the State had prepared a May 13, 1971, Draft Agreement which would have supplemented the Agreement of May 16, 1960.

The United States and the State have in the past been operating under annual letter agreements implementing the May 13, 1971, Draft Agreement.

The United States and the State by entering into this agreement will suspend the Agreement of May 16, 1960; but it is recognized that the legal positions of the parties regarding any interpretation of the terms of said agreement are preserved.

The United States and the State will observe reservoir operational criteria prescribed by the United States Corps of Engineers to minimize flood hazards.

The United States and the State each plans to meet all requirements and objectives of its project and to coordinate the operation of their projects so as not to adversely affect the rights of other parties and to conserve water.

The State and the United States intend to build additional water storage and transportation facilities.

Both the United States and the State have, pursuant to applications filed with the State Water Resources Control Board (formerly State Water Rights Board), received permits for appropriation of unappropriated water in furtherance of their respective projects.

It is in the best interest of the United States and the State to agree on the use of water rights as set forth in this agreement rather than litigate such uses as between the two projects and potentially all other water users in the Central Valley of California.

Both the State and the United States are dedicated to utilizing their existing and future water conservation

facilities so as to provide the maximum benefits to the people of California and the Nation and believe that through the coordinated and cooperative operation of State and Federal facilities, these benefits can be maximized.

NOW, THEREFORE, it is agreed:

DEFINITIONS

3. When used in this agreement, the following shall have the meanings hereinafter set forth:

(a) "Sacramento Valley inbasin uses" are legal uses of water in the Sacramento Basin including the water required under the provisions of Exhibit A.

(b) "Balanced water conditions" are periods when it is agreed that releases from upstream reservoirs plus unregulated flow approximately equal the water supply needed to meet Sacramento Valley inbasin uses, plus exports.

(c) "Excess water conditions" are periods when it is agreed that releases from upstream reservoirs plus unregulated flow exceed Sacramento Valley inbasin uses, plus exports.

(d) "United States storage withdrawal" is the sum of "Whiskeytown storage withdrawal" which is the positive daily mean flow computed by subtracting the daily mean local inflow to Whiskeytown Lake (total inflow excluding the flow through the Judge Francis Carr Powerplant) from the sum of the daily mean diversions from (i) Whiskeytown Lake to Spring Creek Powerplant, (ii) the Whiskeytown Dam releases to Clear

Creek, and (iii) measured water deliveries from Whiskeytown Lake; and the positive sum of:

(1) "Shasta storage withdrawal" which is the daily mean flow computed by subtracting the sum of (i) the daily mean inflow into Shasta Lake and (ii) the daily mean discharge from Spring Creek Powerplant from the sum of (i) the Keswick Dam releases to the Sacramento River and (ii) measured water deliveries from Shasta and Keswick Lakes; and

(2) "Folsom storage withdrawal" which is the daily mean flow computed by subtracting the daily mean inflow into Folsom Lake from the sum of (i) Nimbus Dam releases to the American River, (ii) Nimbus Dam diversions to Folsom South Canal, and (iii) measured water deliveries from Folsom Lake and Nimbus Lake.

(e) "State storage withdrawal" is the value calculated in 3(e)(1) except when specifically declared by the State that Upper Feather storage withdrawals are being made in which case "State storage withdrawal" is the sum of 3(e)(1) and (2).

(1) "Oroville Complex storage withdrawal" is the positive daily mean flow computed by subtracting the sum of the daily mean inflow into Lake Oroville and the daily mean discharge from Kelly Ridge Powerplant from the sum of the daily mean diversions at or into the following facilities:

Palermo Canal, Thermalito Diversion Dam to Feather River, Thermalito Diversion Dam to Hatchery, Diversion Structures for Butte County, Thermalito Irrigation District Diversion Structure, Richvale Canal, Western Canal, Pacific Gas and Electric Company's Lateral, Sutter Butte Canal, and the Thermalito Afterbay Outlet to Feather River.

(2) "Upper Feather River storage withdrawal" is the positive daily mean flow computed by subtracting the sum of the daily mean flow into Lake Davis and Antelope Reservoir from the sum of the daily mean releases from these reservoirs.

(f) "Export" means diversions by the United States and the State through export facilities specified in subarticle 5(b).

(g) "United States stored water" is the net increase in daily storage in Shasta Lake and Folsom Lake.

(h) "State stored water" is the net increase in daily storage in Lake Oroville and, when declared by the State, the net increase in daily storage in the Upper Feather River reservoirs.

(i) "Delta" means the Sacramento-San Joaquin Delta as described in California Water Code §12220 (Stats. 1959, C. 1766, p. 4249, § 1).

(j) "New Delta standards" are any Delta standards different from those set forth in Exhibit A.

TERM OF AGREEMENT

4. This agreement shall remain in full force and effect until terminated either by the mutual consent of the parties or as provided in subarticles 10(h), or 14(b).

FACILITIES

5. This agreement recognizes the following facilities as presently existing:

(a) Reservoirs:

<u>United States</u>	<u>State</u>
Shasta Lake	Lake Oroville
Keswick Reservoir	Thermalito Forebay
Clair Engle Lake	Thermalito Afterbay
Lewiston Lake	Thermalito Diversion Dam Reservoir
Whiskeytown Lake	San Luis Reservoir (Joint)
Folsom Lake	O'Neill Forebay (Joint)
Lake Natoma	Lake Davis
San Luis Reservoir (Joint)	Antelope Lake
O'Neill Forebay (Joint)	Lake Del Valle Pyramid Lake Castaic Lake Silverwood Lake Lake Perris
Millerton Lake	
New Melones	

(b) Export facilities:

<u>United States</u>	<u>State</u>
Contra Costa Pumping Plant #1	Harvey O. Banks Delta Pumping Plant, including Clifton Court Forebay
Tracy Pumping Plant	

COORDINATION OF OPERATIONS

6. (a) This agreement was negotiated on the basis of annual supplies reflected in Exhibit B. It is agreed that:

(1) The computations described in this article shall be the basis upon which the United States and the State shall coordinate the operations of the Central Valley Project and the State Water Project facilities specified in Article 5 in order to meet Sacramento Valley inbasin uses and maintain the respective annual water supplies specified in Exhibit B-1, or as that exhibit is revised in accordance with subarticle 6(a)(3);

(2) Nothing in this agreement shall constrain either party from moving toward full utilization of its facilities at any time;

(3) As either party proceeds toward the full utilization of its project, any changes in the underlying assumptions with respect to the development of the two projects and the demands for water from each project will be reflected by recomputing the annual water supplies specified

in Exhibits B-1 and B-2 in accordance with the provisions of subarticle 14(a). The methodology described in the document entitled "Technical Report on Determination of Annual Water Supplies for Central Valley Project and State Water Project," dated March 1984 will be used to recompute the annual water supplies and to revise, if necessary, the factors and procedures contained in this article.

(b) Determination of Sacramento Valley Inbasin

Use of Storage Withdrawals and Unstored Water for Export:

During period of balanced water conditions, daily computation shall be made to determine the difference between (i) the sum of the United States and State storage withdrawals adjusted for time of travel to the export facilities specified in subarticle 5(b), and (ii) the sum of the United States and State exports. If total storage withdrawals exceed total exports, the difference represents Sacramento Valley inbasin use of storage withdrawals. If total exports exceed storage withdrawals, the difference represents unstored water for export.

(c) Sharing of Responsibility for Meeting Sacramento Valley Inbasin use With Storage Withdrawals During Balanced Water Conditions: Each party's responsibility for making available storage withdrawals to meet Sacramento Valley

inbasin use of storage withdrawals shall be determined by multiplying the total Sacramento Valley inbasin use of storage withdrawals by the following percentages:

<u>United States</u>	<u>State</u>
75	25

(d) Sharing of Responsibility During Balanced Water Conditions When Unstored Water for Export is Available:
Each party's responsibility to meet Sacramento Valley inbasin use and exports shall be determined by:

(1) Allocating the sum of United States stored water, State stored water and the unstored water for export by the following percentages:

<u>United States</u>	<u>State</u>
55	45

(2) If the daily sum of United States stored water and unstored water for export is greater than the United States share as allocated in 6(d)(1), then the United States is obligated, except when either subarticle 6(h) or 6(i) is in effect, to provide water to the extent that its daily sum is greater than its allocated share.

(3) If the daily sum of United States stored water and the unstored water for export is less than its share as allocated in 6(d)(1) then the State is obligated, except when either subarticle 6(h) or 6(i) is in effect, to

provide water to the extent that the State's daily sum of State stored water and unstored water used for export is greater than its allocated share.

(e) Accounting of Accumulated Responsibilities:

During balanced conditions, except when either sub-article 6(h) or 6(i) is in effect, the daily obligation as defined in subarticle 6(c) or 6(d) shall be accumulated. The accumulation in effect when balanced conditions end shall remain in force and resume when balanced conditions are again declared. At the request of either party, the accumulation will be reduced or eliminated within a reasonable time.

Otherwise, the accumulation shall continue until the agency that has the positive accumulation (has released more water than its defined responsibility) goes into a flood control operation. A flood control operation occurs when the actual storage exceeds the defined flood control permissible storage at Oroville Reservoir for the State or Shasta Reservoir for the United States. The flood control operation at Folsom Reservoir will not affect this provision because of its limited conservation storage.

(f) Changes in Sacramento Valley Inbasin Use

During Balanced Conditions: If the Sacramento Valley inbasin use changes, upstream reservoir releases and/or exports will be modified based on the current accumulation identified in subarticle 6(e) and/or the daily share of responsibility computed in subarticles 6(c) and 6(d).

(g) Responsibilities During Excess Water

Conditions: During excess water conditions each party has the responsibility to export and store as much water as possible within its physical and contractual limits.

(h) Availability of Storage Withdrawals to the

Other Party: Unless otherwise agreed, whenever a party's storage withdrawal available for export is greater than its export capability, the difference shall be available for export by the other party without affecting either party's future responsibility for providing storage withdrawals to meet Sacramento Valley inbasin use.

(i) Availability of Unstored Water for Export

to the Other Party: Unless otherwise agreed, whenever a party's share of unstored water for export exceeds its exports, the unusable portion is available for export by the other party without affecting either party's daily sum of stored water.

FORECASTING

7. Upon request, each party shall prepare and furnish to the other a forecast of its proposed operation related to the facilities specified in Article 5. The forecast shall indicate the flow available for export, storage withdrawals, and Sacramento Valley inbasin use. The forecasts shall be prepared and exchanged so as to allow sufficient time for the preparation of consolidated forecasts.

WATER MEASUREMENT RESPONSIBILITIES

8. The United States and the State, each at its own expense, shall install and maintain measuring and recording devices at its facilities specified in Article 5.

(a) Each party shall measure or compute and record daily, or at such other intervals as may be agreed upon, and provide to the other party the rates and quantities of water that will show the (1) estimated inflow to its reservoirs, (2) net releases from its reservoirs, (3) stage and change in storage of its reservoirs, (4) net amount of evaporation at its reservoirs, (5) diversions through its export facilities, and (6) its storage withdrawals.

(b) The measuring and recording devices shall be examined, tested, and serviced regularly to assure their accuracy. At any reasonable time either party may inspect the measuring and recording devices of the other party. Immediate action shall be taken to correct any deficiencies noted in such inspections. Accuracy in measurements of export diversions and releases from reservoirs shall be within commonly accepted engineering standards. All computations and correlations shall be calculated in a manner acceptable to both parties.

REDUCTION IN UNITED STATES AND STATE EXPORTS

9. If any forecast indicates that either the United States or the State, or both, will be unable to meet the anticipated demands of its water users during the balance of

the calendar year, representatives of the United States and the State shall confer on possible procedures for making joint operational changes to minimize the shortage. If agreement cannot be reached on a joint procedure for minimizing the threatened shortage, the United States and the State each shall be entitled to export the amount of water available to it according to calculations made pursuant to Article 6, and each party shall assess against its users such reductions as it deems necessary or appropriate.

EXCHANGES, CONVEYANCE, AND PURCHASES OF WATER SUPPLY

10. (a) Either party may make use of its facilities available to the other party for pumping and conveyance of water by written agreement.

(b) To the extent that operational constraints are imposed on the Central Valley Project by Exhibit A to minimize diversions of young striped bass from the Delta during May and June, which reduce Central Valley Project exports, the State will transport up to 195,000 acre-feet of Central Valley Project water through the California Aqueduct Reaches 1, 2A, and 2B no later than April 30 of the following year by direct diversion or by rediversion of stored Central Valley Project water at times that diversions do not reduce State Water Project yield.

The State agrees to transport this water subject to the following:

(1) The United States will supply power according to Exhibit D;

(2) During critical water supply years, as defined by D-1485, the State shall pump the water during Central Valley Project off-peak hours (10:01 p.m. to 6:59 a.m. Monday through Saturday and all day Sunday and national holidays);

(3) In all other water supply years, to the extent possible as determined by the State, pumping of this water shall be provided during Central Valley Project off-peak hours;

(4) The United States shall reimburse the State for incremental costs for pumping Central Valley Project water through the facilities specified in this subarticle. Incremental costs are those costs which if not reimbursed by the United States would otherwise cause increased charges to State Water Project water contractors over what they would have been charged if the State had not conveyed Central Valley Project water pursuant to this agreement, provided that the United States shall not be responsible for payment for any additional power demand charges that may result from pumping Central Valley Project water pursuant to subarticle 10(b). At present, the only incremental costs identified by the State are the replacement portions of the minimum and variable components of both the Delta Water Charge and Transportation Charge, as defined in

the November 4, 1960, State Water Supply Contract with The Metropolitan Water District of Southern California, as it now exists and may hereafter be amended. Incremental costs in 1985 amounted to \$0.21 per acre-foot of water conveyed.

(c) The State agrees to give priority to the United States to convey Central Valley Project water for scheduled or unscheduled maintenance and unforeseen outages of the Central Valley Project, from the Delta to O'Neill Forebay, not covered in subarticles 10(b) and 10(d), through the California Aqueduct Reaches 1, 2A, and 2B facilities at times that such conveyance does not reduce use of the State's facilities for the benefit of the State's long-term water supply contractors subject to the following:

(1) The United States will supply the power required to pump Central Valley Project water through the Harvey O. Banks Delta Pumping Plant;

(2) The State will be reimbursed for each of the following charges expressed as a unit rate and applied to each acre-foot of water conveyed. These charges will equal the sum of the components of the water charges for California Aqueduct Reaches 1, 2A, and 2B as defined in the State Water Supply Contract with the Metropolitan Water District of Southern California, dated November 4, 1960, as it now exists and may hereafter be amended.

(i) The capital component of the transportation charge.

(ii) The minimum component of the transportation charge.

(iii) The replacement portion of the variable component of the transportation charge.

(iv) The capital component of the Delta water charge.

(v) The minimum component of the Delta water charge.

These charges for 1985 total \$8.44 per acre-foot of water conveyed.

(d) In consideration for the conveyance of State Water Project water for scheduled or unscheduled maintenance and unforeseen outages from the Delta to O'Neill Forebay through Central Valley Project facilities, the State will convey for the United States an equal quantity of Central Valley Project water measured in acre-feet through its facilities at no charge; Provided, That such conveyance of Central Valley Project water shall be accomplished, if possible, within 12 months from the date conveyance of State Water Project water was completed. Each agency shall be responsible for supplying the power required to pump its water.

(e) The State, in an annual letter to the United States, will transmit the charges referred to in subarticles 10(b)(2) and 10(c)(2) above based upon the cost components listed therein.

(f) The State will submit invoices to the United States on or before June 30 of the year following the year in which the wheeling occurs. The United States will make payment within 30 days after receipt of such invoice.

(g) Prior to December 31 of the fifth full year following the execution of this agreement, the parties will agree upon the amount and value of the services each project has provided to the other project prior to the execution of this agreement and will agree upon the manner in which any imbalance is to be resolved. This subarticle shall not apply to services provided under a separate written agreement.

(h) (1) The parties shall promptly commence negotiating a contract for the conveyance and purchase of Central Valley Project water to assist each party in making more efficient use of the water project facilities and water supplies contemplated in this agreement. The terms and conditions of said contract shall be no less favorable to either party than the terms and conditions either party would make available to their respective long-term contractors, except as specified by this subarticle.

(2) The contract referred to in subarticle 10(h)(1) shall provide for, among other things, the sale of Central Valley Project water to the State for use by State Water Project contractors on the following conditions:

(i) When the Central Valley Project water sold to the State is needed by existing or new long-term Central Valley Project contractors, it shall be recalled by the United States for such contractors;

(ii) The United States shall impose deficiencies on water purchased by the State in a manner consistent with Exhibit E.

(3) The contract referred to in subarticle 10(h)(1) shall further provide for, among other things, the United States purchase of State Water Project conveyance services for transport of Central Valley Project water to Central Valley Project contractors on the following conditions:

(i) The State shall transport Central Valley Project water for the United States up to the amount of Central Valley Project water made available to the State for purchase each year on the same priority as water transported for State Water Project long-term contractors;

(ii) In addition, the United States shall have the first right to purchase all conveyance services that are in excess of the services being used to transport water

developed or purchased by the State or the State Water Project contractors. The conveyance of Central Valley Project water shall not diminish deliveries or increase costs of water supplies developed or purchased by the State or the State Water Project contractors.

(4) The parties recognize that to fully implement this agreement, the parties may be required to seek amendments to existing water rights permits or additional water rights permits for, (i) an additional point of diversion and rediversion at the State's Harvey O. Banks Delta Pumping Plant and the United States Tracy Pumping Plant; and (ii) consolidation and expansion of place of use. The State shall support the petition of the United States.

(5) At any time after December 31, 1988, if either party shall not have received all of the amendments or permits described in subarticle 10(h)(4) and which contain conditions satisfactory to that party, then that party may terminate this agreement on 180 days written notice, or utilize the provisions of subarticle 14(b)(2) to seek a resolution of its concerns.

DELTA STANDARDS

11. (a) The Central Valley Project and the State Water Project will be operated in conformity with the Delta standards in Exhibit A. Should the State Water Resources

Control Board establish new Delta standards, and the United States determines that operation of the Central Valley Project in conformity with the new Delta standards is not inconsistent with Congressional directives the parties shall amend Exhibit A to conform with the new Delta standards and amend this agreement to the extent necessary to provide for continued operation of both projects to accomplish the purposes of this agreement.

(b) Should the United States determine that the new Delta standards are inconsistent with Congressional directives then the United States shall promptly request the Department of Justice to bring an action for the purpose of determining the applicability of the new Delta standards to the Central Valley Project.

(c) The United States reserves the right to seek, at any time, the enactment of legislation regarding the operation of the Central Valley Project, including compliance with new Delta standards, which may supersede any final court decisions addressed in subarticle 11(b).

(d) The parties do not intend by this agreement to confer any additional authority upon either the Secretary of the Interior or the State Water Resources Control Board beyond that derived from applicable statutory and decisional law.

MONITORING

12. (a) The United States and the State recognize that certain monitoring activities must be done to ensure compliance with the Delta standards specified in Exhibit A. The necessary monitoring activities are specified in Exhibit C. The United States and the State agree to share equally the cost of those monitoring activities, including the analysis of the collected data.

(b) Exhibit C will be amended, if necessary, to ensure compliance with any Delta standards different from those set forth in Exhibit A which are applicable to the United States pursuant to Article 11.

(c) The parties agree that additional data must be collected and processed to determine the effects of the projects on the Delta and San Francisco Bay. Monitoring in addition to that specified in Exhibit C and the performance of Delta water quality studies will be covered by separate agreements.

RECORDS

13. Subject to applicable laws and regulations, the United States and the State shall have full access at all reasonable times to the books and records of the other party insofar as they pertain to this agreement, with the right to make copies thereof.

PERIODIC REVIEW

14. (a) Prior to December 31 of the fifth full year following execution of this agreement, and before December 31 of each fifth year thereafter, or more frequently if so requested by either party, the United States and the State jointly shall review the operations of both projects. The parties shall (1) compare the relative success which each party has had in meeting its objectives, (2) review operation studies supporting this agreement, including, but not limited to, the assumptions contained therein, and (3) assess the influence of the factors and procedures of Article 6 in meeting each party's future objectives. The parties shall agree upon revisions, if any, of the factors and procedures in Article 6, Exhibits B and D, and the Operation Study used to develop Exhibit B.

(b) (1) If the parties fail to enter into the contract referred to in subarticle 10(h)(1) by December 31, 1988, either party may give written Notice of Negotiation to the other party. Within 30 days of such notice, each party shall designate one member of an Advisory Board to which that problem shall be referred. The members designated by the parties shall choose a third member who shall act as chairperson. The Board shall report its unanimous recommendation to both parties with respect to all terms and conditions to be

included in said contract at a date not later than 12 months from the date of the Notice of Negotiation. The parties shall immediately implement that recommendation. If the Board fails to make a unanimous recommendation within the 12-month period, either party may unilaterally terminate this agreement.

(2) If the parties are unable to agree on changes to this agreement, or either party fails to receive all of the amendments or permits described in subarticle 10(h)(4), either party may give written Notice of Negotiation. If agreement satisfactory to both parties has not been reached within 12 months of such Notice, each party shall designate within 30 days one member of an Advisory Board to which the problem shall be referred. The members designated by the parties shall choose a third member who shall act as chairperson. The Board shall report its unanimous recommendations to both parties at a date not later than 24 months from the date of the Notice of Negotiation and the parties shall amend this agreement and immediately begin to operate in accordance with said recommendations. If the Board fails to make unanimous recommendations within the 24-month period, either party may unilaterally terminate this agreement.

RELATION TO AGREEMENT OF MAY 16, 1960

15. This agreement suspends the Agreement of May 16, 1960, and said Agreement of May 16, 1960, shall be of no force and effect whatsoever so long as this agreement remains in force. Should this agreement be terminated for any purpose, the Agreement of May 16, 1960, shall automatically become effective with both parties reserving their respective rights regarding the interpretation of the provisions thereof.

NEW FACILITIES

16. Any yield created by the construction of a new facility (not presently existing) by either party shall be attributed to the party constructing the new facility, and will require a review as provided for in Article 14. To the extent that water is exported outside the drainage of the Sacramento, Mokelumne, and Calaveras Rivers, the facilities used to convey such water shall be considered as export facilities for the purposes of Article 5.

PROJECT SERVICE AREAS

17. The State and the United States agree that they will respect each others project service areas as defined by long-term contracts of either agency for the furnishing of water.

THIRD PARTY RIGHTS UNAFFECTED

18. Nothing in this agreement is intended to define, determine, limit, or affect the rights of third parties.

EFFECT OF WAIVER OF BREACH

19. The waiver of a breach of any of the provisions of this agreement shall not be deemed to be a waiver of any other provisions hereof or of a subsequent breach of such provisions.

EQUAL EMPLOYMENT OPPORTUNITIES

20. During the performance of this agreement, the State agrees as follows:

(a) It will not discriminate against any employee or applicant for employment because of race, color, religion, sex, or national origin. It will take affirmative action to ensure that applicants are employed, and that employees are treated during employment without regard to their race, color, religion, sex, or national origin. Such action shall include, but not be limited to, the following: Employment,

upgrading, demotion, or transfer; recruiting or recruitment advertising; layoff or termination; rates of pay or other forms of compensation; and selection for training, including apprenticeship. It agrees to post in conspicuous places, available to employees and applicants for employment, notices to be provided by the Contracting Officer setting forth the provisions of this Equal Opportunity clause.

(b) The State will, in all solicitations or advertisements for employees placed by or on its behalf, state that all qualified applicants will receive consideration for employment without regard to race, color, religion, sex, or national origin.

(c) The State will send to each labor union or representative of workers with which it has a collective bargaining agreement or other contract or understanding a notice, to be provided by the agency Contracting Officer, advising the labor union or workers' representative of the State's commitments under this Equal Opportunity clause, and shall post copies of the notice in conspicuous places available to employees and applicants for employment.

(d) The State will comply with all provisions of Executive Order No. 11246 of September 24, 1965, as amended, and of the rules, regulations, and relevant orders of the Secretary of Labor.

(e) The State will furnish all information and reports required by said Executive Order, and by the rules, regulations, and orders of the Secretary of Labor, or pursuant thereto, and will permit access to its books, records, and accounts by the Bureau of Reclamation and the Secretary of Labor for purposes of investigation to ascertain compliance with such rules, regulations, and orders.

(f) In the event of the State's noncompliance with the Equal Opportunity clause of this contract or with any of the said rules, regulations, or orders, this contract may be canceled, terminated, or suspended in whole or in part, and it may be declared ineligible for further Government contracts in accordance with procedures authorized in said Executive Order, and such other sanctions may be imposed and remedies invoked as provided in said Executive Order, or by rule, regulation, or order of the Secretary of Labor, or as otherwise provided by law.

(g) The State will include the provisions of paragraphs (a) through (g) in every subcontract or purchase order unless exempted by rules, regulations, or orders of the Secretary of Labor issued pursuant to Section 204 of Executive Order No. 11246, so that such provisions will be binding upon each subcontractor or vendor. It will take such actions with respect to any subcontract or purchase order as the Contracting

Officer may direct as a means of enforcing such provisions, including sanctions for noncompliance; Provided, however, That in the event the State becomes involved in, or is threatened with, litigation with a subcontractor or vendor as a result of such direction by the Contracting Officer it may request the United States to enter into such litigation to protect the interests of the United States.

CONTINGENT PROVISIONS

21. Performance by the State and the United States shall be contingent on: (1) the availability of Federal funds therefor; and (2) the availability of State funds therefor.

OFFICIALS NOT TO BENEFIT

22. (a) No member of or Delegate to Congress or Resident Commissioner shall be admitted to any share or part of this agreement or to any benefit that may arise herefrom. This restriction shall not be construed to extend to this agreement if made with a corporation for its general benefit.

(b) No official of the State shall receive any benefit that may arise by reason of this agreement other than as a landowner within the Project and in the same manner as other landowners within the Project.

IN WITNESS WHEREOF, the parties hereto, by their respective officers thereunto duly authorized, have duly executed this supplement on the day and year first hereinabove written.

THE UNITED STATES OF AMERICA

By _____
Regional Director, Mid-Pacific Region
Bureau of Reclamation

DEPARTMENT OF WATER RESOURCES OF
THE STATE OF CALIFORNIA

By _____
Director
Department of Water Resources

STANDARDS
FOR THE SACRAMENTO-SAN JOAQUIN DELTA 1/

BENEFICIAL USES PROTECTED AND LOCATION	PARAMETER	DESCRIPTION	YEAR TYPE	VALUES
<u>MUNICIPAL AND INDUSTRIAL</u>				
Contra Costa Canal Intake at Pumping Plant No. 1	Chloride	Maximum Mean Daily Cl ⁻ in mg/l	All	250
Contra Costa Canal Intake At Pumping Plant No. 1 or Antioch Water Works Intake on San Joaquin River	Chloride	Maximum Mean Daily 150 mg/l Chloride for at least the number of days shown during the Calendar Year. Must be provided in intervals of not less than two weeks duration (% of Year shown in parenthesis)	Wet Ab. Normal Bl. Normal Dry Critical	Number of Days Each Calendar Year Less than 150 mg/l Chloride 240 (66%) 190 (52%) 175 (48%) 165 (45%) 155 (42%)
City of Vallejo Intake at Cache Slough	Chloride	Maximum Mean Daily Cl ⁻ in mg/l	All	250
Clifton Court Forebay Intake at West Canal	Chloride	Maximum Mean Daily Cl ⁻ in mg/l	All	250
Delta Mendota Canal at Tracy Pumping Plant	Chloride	Maximum Mean Daily Cl ⁻ in mg/l	All	250
<u>AGRICULTURE</u>				
WESTERN DELTA				
Emmerton on the Sacramento River	Electrical Conductivity	Maximum 14-day Running Average of Mean Daily EC in mmhos	Wet Ab. Normal Bl. Normal Dry Critical	0.45 EC April 1 to Date Shown Aug. 15 EC from Date Shown 2/ to Aug. 15 -- 0.63 1.14 1.67 2.78
EXHIBIT A				1 of 7

BDCP1563.

BENEFICIAL USES PROTECTED AND LOCATION	PARAMETER	DESCRIPTION	YEAR TYPE	VALUES
AGRICULTURE				
WESTERN DELTA				
Jersey Point on the San Joaquin River	Electrical Conductivity	Maximum 14-day Running Average of Mean Daily EC in mmhos	Wet Ab. Normal Bl. Normal Dry Critical	0.45 EC April 1 to Date Shown
				EC from Date Shown 2/ to Aug. 15
				Aug. 15
				Aug. 15
				June 20
				0.74
				1.35
				2.20
INTERIOR DELTA				
Terminous on the Mokelumne River	Electrical Conductivity	Maximum 14-day Running Average of Mean Daily EC in mmhos	Wet Ab. Normal Bl. Normal Dry Critical	Aug. 15
				Aug. 15
				Aug. 15
				Aug. 15
				Aug. 15
				0.54
San Andreas Landing on the San Joaquin River	Electical Conductivity	Maximum 14-day Running Average of Mean Daily EC in mmhos	Wet Ab. Normal Bl. Normal Dry Critical	Aug. 15
				Aug. 15
				Aug. 15
				Aug. 15
				June 25
				0.58
				0.87
FISH AND WILDLIFE				
STRIPED BASS SPAWNING				
Prisoners Point on the San Joaquin River	Electrical Conductivity	Average of mean daily EC for the period not to exceed	All	April 1 to May 5 0.55 mmhos
Chipps Island	Delta Outflow Index in cfs	Average of the daily Delta outflow index for the period, not less than	All	April 1 to April 14 6700 cfs
Antioch Waterworks Intake on the San Joaquin River	Electrical Conductivity	Average of mean daily EC for the period, not more than	All	April 15 to May 5 1.5 mmhos

BENEFICIAL USES PROTECTED
AND LOCATION

PARAMETER DESCRIPTION YEAR TYPE VALUES

FISH AND WILDLIFE

STRIPED BASS SPAWNING

Antioch Water Works Intake (continued)	Electrical Conductivity (Relaxation Provision - replaces the above Antioch and Chipps Island Stan- dard whenever the projects impose defi- ciencies in firm supplies ^{3/}	Average of mean Daily EC for the period, not more than the values correspond- ing to the deficiencies taken (linear interpola- tion to be used to deter- mine values between those shown)	All - whenever the pro- jects im- pose defi- ciencies in firm supplies ^{3/}	Total Annual Imposed Defi- ciency MAF	Apr. 1 to May 5 EC in mmhos
				0	1.5
				0.5	1.9
				1.0	2.5
				1.5	3.4
				2.0	4.4
				3.0	10.3
				4.0 or more	25.2

STRIPED BASS SURVIVAL

Chipps Island	Delta Outflow Index in cfs	Average of the daily Delta outflow index for each period shown not less than	Wet Ab. Normal Bl. Normal Subnormal Snowmelt Dry ^{4/} Dry ^{5/} or Critical	May 6-31 14,000 14,000 11,400 6,500 4,300 3,300	June 14,000 10,700 9,500 5,400 3,600 3,100	July 10,000 7,700 6,500 3,600 3,200 2,900
---------------	-------------------------------	--	---	---	--	---

SALMON MIGRATIONS

Rio Vista on the Sacramento River	Computed net stream flow in cfs	Minimum 30-day running average of mean daily net flow	Wet Ab. Normal Bl. Normal Dry or Critical	Jan. 2,500 2,500 2,500 1,500	Feb. 1- Mar. 15 3,000 2,000 2,000 1,000	Mar. 16- June 30 5,000 3,000 3,000 2,000
--------------------------------------	---------------------------------------	---	---	--	--	---

BDCP1563.

BENEFICIAL USES PROTECTED
AND LOCATION

PARAMETER DESCRIPTION YEAR TYPE VALUES

FISH AND WILDLIFE

SALMON MIGRATIONS

Rio Vista on the
Sacramento River
(continued)

			Sept. 1 Dec. 31
		July	Aug.
	Wet	3,000	1,000
	Ab. Normal	2,000	1,000
	Bl. Normal	2,000	1,000
	Dry or		
	Critical	1,000	1,000
			1,500

SUISUN MARSH

Chippis Island at
O&A Ferry LandingElectrical
ConductivityMaximum 28-day running
average of mean daily EC

		Jan.-May	Oct.-Dec.
	Wet	12.5 mmhos	12.5 mmhos
	Ab. Normal	12.5 mmhos	12.5 mmhos
	Bl. Normal	12.5 mmhos	12.5 mmhos
	Dry or		
	Critical	12.5 mmhos	15.6 mmhos

(The 15.6 mmhos EC Standard applies only when project water users are taking deficiencies in scheduled water supplies 6/ otherwise the 12.5 mmhos EC remains in effect.)

Chippis Island

Delta Outflow
Index in cfsAverage of the daily
Delta outflow index for
each month, not less
than values shownWet
Subnormal
Snowmelt

February-May	February-April
10,000 cfs	10,000 cfs

Minimum daily Delta
outflow index for 60
consecutive days in
the periodAb. Norm and
Bl. Norm.

January-April	12,000 cfs
---------------	------------

BENEFICIAL USES PROTECTED AND LOCATION

FISH AND WILDLIFE

SUISUN MARSII

Chippis Island
(continued)

Delta Outflow
Index in cfs

Average of the daily
Delta outflow index for
each month, not less
than values shown

All (if greater
flow not required
by above standard)
- whenever storage
is at or above the
minimum level in
the flood control
reservation en-
velope at two out
of three of the
following: Shasta
Reservoir, Oroville
Reservoir, and CVP
storage on the
American River

Jan.-May
6,600 cfs

OPERATIONAL CONSTRAINTS *

Minimize diversion of
young striped bass
from the Delta

Diversions
in cfs

The mean monthly diver-
sions from the Delta by
the State Water Project (SWP)
(Department) not to
exceed the values shown.
The mean monthly diver-
sions from the Delta by
the Central Valley Project (CVP)
(Bureau), not to exceed
the values shown.

May June July
3,000 3,000 4,600

May June
3,000 3,000

Minimize diversion of
young striped bass into
Central Delta

Closure of Delta cross
channel gates for up to
20 days but no more than
two out of four consecu-
tive days at the dis-
cretion of the Department
of Fish and Game upon 12
hour notice.

April 16-May 31

BDCP1563.

BENEFICIAL USES PROTECTED AND LOCATION	PARAMETER	DESCRIPTION	YEAR TYPE	VALUES
<u>FISH AND WILDLIFE</u>				
OPERATIONAL CONSTRAINTS *				
Minimize cross Delta movement of Salmon		Closure of Delta Cross Channel gates (whenever the daily Delta outflow index is greater than 12,000 cfs)	All	<u>Jan. 1-April 15</u>

*To the extent that operational constraints on the Central Valley Project to minimize diversion of young striped bass from the Delta during May and June reduce Central Valley Project exports, the State will, through coordinated operations, transport for the United States an amount equal to such reductions during the year by direct diversion or by redirection of stored Central Valley Project water through State Water Project facilities at such times that diversions don't reduce State Water Project yield.

FOOTNOTES

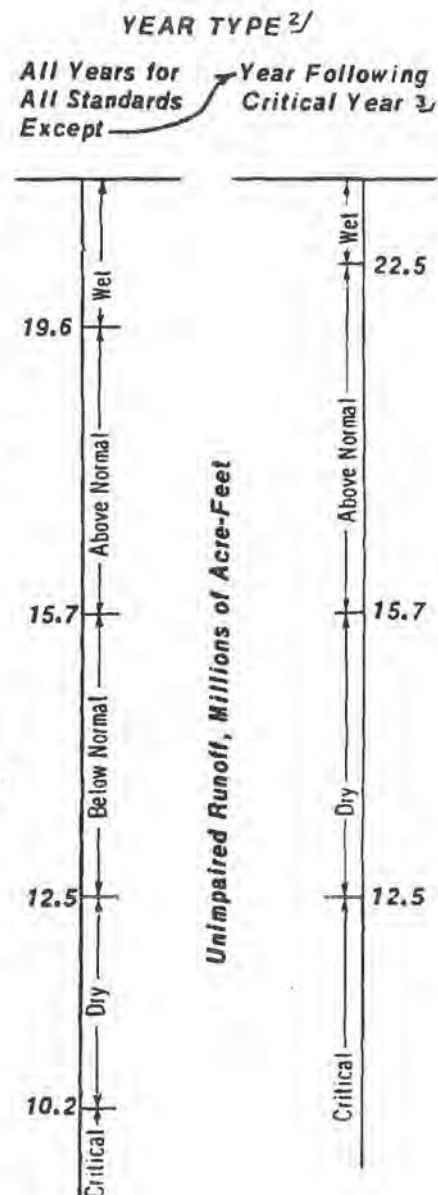
- 1/ Except for flow, all values are for surface zone measurements. Except for flow, all mean daily values are based on at least hourly measurements. All dates are inclusive.
- 2/ When no date is shown in the adjacent column, EC limit in this column begins on April 1.
- 3/ For the purpose of this provision firm supplies of the Bureau shall be any water the Bureau is legally obligated to deliver under any CVP contract of 10 years or more duration, excluding the Friant Division of the CVP, subject only to dry and critical year deficiencies. Firm supplies of the Department shall be any water the Department would have delivered under Table A entitlements of water supply contracts and under prior right settlements had deficiencies not been imposed in that dry or critical year.
- 4/ Dry year following a wet, above normal or below normal year.
- 5/ Dry year following a dry or critical year.
- 6/ Scheduled water supplies shall be firm supplies for USBR and DWR plus additional water ordered from DWR by a contractor the previous September, and which does not exceed the ultimate annual entitlement for said contractor.

NOTE: EC values are mmhos/cm at 25°C.

YEAR CLASSIFICATION

Year classification shall be determined by the forecast of Sacramento Valley unimpaired runoff for the current water year (October 1 of the preceding calendar year through September 30 of the current calendar year) as published in California Department of Water Resources Bulletin 120 for the sum of the following locations: Sacramento River above Bend Bridge, near Red Bluff; Feather River, total inflow to Oroville Reservoir; Yuba River at Smartville; American River, total inflow to Folsom Reservoir. Preliminary determinations of year classification shall be made in February, March and April with final determination in May. These preliminary determinations shall be based on hydrologic conditions to date plus forecasts of future runoff assuming normal precipitation for the remainder of the water year.

YEAR TYPE	RUNOFF, MILLIONS OF ACRE-FEET
Wet ^{1/}	equal to or greater than 19.6 (except equal to or greater than 22.5 in a year following a critical year). ^{2/}
Above Normal ^{1/}	greater than 15.7 and less than 19.6 (except greater than 15.7 and less than 22.5 in a year following a critical year). ^{2/}
Below Normal ^{1/}	equal to or less than 15.7 and greater than 12.5 (except in a year following a critical year). ^{2/}
Dry	equal to or less than 12.5 and greater than 10.2 (except equal to or less than 15.7 and greater than 12.5 in a year following a critical year). ^{2/}
Critical	equal to or less than 10.2 (except equal to or less than 12.5 in a year following a critical year). ^{2/}



- ^{1/} Any otherwise wet, above normal, or below normal year may be designated a subnormal snowmelt year whenever the forecast of April through July unimpaired runoff reported in the May issue of Bulletin 120 is less than 5.9 million acre-feet.
- ^{2/} The year type for the preceding water year will remain in effect until the initial forecast of unimpaired runoff for the current water year is available.
- ^{3/} "Year following critical year" classification does not apply to Agricultural, Municipal and Industrial standards.

EXHIBIT B-1CENTRAL VALLEY PROJECT AND STATE WATER PROJECT ANNUAL SUPPLIES
(all figures are in thousands of acre-feet)

<u>Central Valley Project</u>		<u>State Water Project</u>		<u>Total</u>
<u>SACRAMENTO BASIN USE</u>				
Sacramento River below Shasta	2,954	Feather River below Oroville	993	
American River Basin	<u>200</u>		<u>—</u>	
Subtotal	3,154		993	4,147
<u>EXPORT</u>				
Tracy Pumping Plant	3,113	Delta Pumping Plant	2,674	
Contra Costa Pumping Plant	90			
Cross Valley Canal	128			
Incremental Supply	432			
	<u>—</u>		<u>—</u>	
Subtotal	3,762		2,674	6,436
DELTA AREA AND OUTFLOW (JOINT RESPONSIBILITY)				<u>4,986</u>
TOTAL				15,569

- Notes: (1) Annual supplies are based on operation study USCAL-2-82.
(1928-1934 critical period)
- (2) Annual supplies in some cases include both water right entitlements and project supplemental water.
- (3) The listing of annual supplies by service areas is not intended to restrict the place of use of either party.
- (4) Cross Valley Canal supply relies on transport through State Water Project facilities.
- (5) Incremental supply is developed from remaining storage in Central Valley Project reservoirs at the end of the 1928-1931 critical period and could be made available in the Delta on a firm basis with allowable (25%) deficiencies in critical years. It would require transport through State Water Project facilities.

EXHIBIT B-2CENTRAL VALLEY PROJECT AND STATE WATER PROJECT FULL DEVELOPMENT ANNUAL SUPPLIES
(all figures are in thousands of acre-feet)

<u>Central Valley Project</u>		<u>State Water Project</u>		<u>Total</u>
<u>SACRAMENTO BASIN USE</u>				
Sacramento River below Shasta	3,381	Feather River below Oroville	1,031	
American River Basin	<u>1,132</u>		<u> </u>	
Subtotal	4,513		1,031	5,544
<u>EXPORT</u>				
Tracy Pumping Plant	3,264	Delta Pumping Plant	2,059	
Contra Costa Pumping Plant	195			
Cross Valley Canal	128			
Incremental Supply	154			
	<u> </u>		<u> </u>	
Subtotal	3,741		2,059	5,800
DELTA AREA AND OUTFLOW (JOINT RESPONSIBILITY)				<u>4,918</u>
TOTAL				16,262

- Notes: (1) Figures are illustrative of annual supplies obtainable under the assumptions of operation study USCAL-3-82. (1928-1934 critical period) which assumes full development with existing facilities.
- (2) Annual supplies in some cases include both water right entitlements and project supplemental water.
- (3) The listing of annual supplies by service areas is not intended to restrict the place of use of either party.
- (4) Cross Valley Canal supply relies on transport through State Water Project facilities.
- (5) Incremental supply is developed from remaining storage in Central Valley Project reservoirs at the end of the 1928-1934 critical period and could be made available in the Delta on a firm basis with allowable (25%) deficiencies in critical years. It would require transport through State Water Project facilities.
- (6) American River Basin Supply includes 120 thousand acre-feet for Placer County Water Agency water rights. It is assumed delivered above Folsom.

EXHIBIT CMONITORING LOCATIONS

<u>No.</u>	<u>*Station Identifier Code</u>	<u>State Location</u>
1	RSAN032	San Joaquin River at San Andreas Landing
2	CHCCC06	Contra Costa Canal at P.P. #1
3	CHWST0	West Canal at mouth/intake to CCFB
4	RSMKL08	Mokelumne River at Terminous
5	SLCCH16	Cache Slough at City of Vallejo intake
6	RSAC075	Sacramento River at Chipps Island (Mallard Slough)
7	RSAN007	San Joaquin River at Antioch
8	RSAN018	San Joaquin River at Jersey Point
9	RSAC092	Sacramento River at Emmaton
10	CHDMC006	Delta Mendota Canal
11	RSAC101	Sacramento River at Rio Vista
12	RSAC139	Sacramento River at Greens Landing
13	ROLD14	Old River at Holland Tract
14	RSAC081	Sacramento River at Collinsville
15	RSAN112	San Joaquin River at Vernalis
16	B9D801.9 143.2	San Joaquin River at Blind Point
17	**D29	San Joaquin River at Prisoners Point
18	B9D802.0 137.2	Piper Slough at Bethel Island

Unless otherwise agreed, a continuous electrical conductivity (EC) recorder shall be maintained at all of the sites listed above except for the San Joaquin River at Prisoners Point (D29) where only a weekly EC measurement is required between April 1 and May 5 of each year.

*Station Identifier Code used in the Environmental Protection Agency STORET data base.

**Bureau of Reclamation station identifier code. STORET code not available.

Exhibit D
Exchange Procedure to Provide D-1485 Condition 3
Replacement Water (Article 10b of COA)

The California State Water Resources Control Board (SWRCB) Decision 1485 (D-1485) restricts exports from the Delta by the Central Valley Project (CVP) and the State Water Project (SWP) during May and June of each year by limiting each project to a mean monthly export of 3,000 ft³/s. However, Condition 3 of D-1485¹ allows the CVP to make up any deficiency caused by the limitation by exporting at SWP facilities (Condition 3 water). In an effort to minimize the impact of the limitation on CVP and SWP power operations and unless otherwise agreed, this exchange procedure will be followed.

During May and June of each year the CVP shall have the option to provide and the SWP will accept an amount of energy on a mutually agreed upon schedule sufficient to pump some or all Condition 3 water at H. O. Banks Delta Pumping Plant (Banks). Operation under this procedure shall not cause export from the Delta in excess of that shown in Exhibit A. Any energy supplied by the CVP under this procedure will be used for pumping of SWP water at Banks and/or any joint CVP-SWP pumping facility during May and June. Such energy shall be converted to dollars at the then current value of SWP energy and credited to a CVP exchange account (account). During months other than May and June, the SWP shall pump Condition 3 water for the CVP utilizing the account to cover

1

To the extent that operational constraints on the Central Valley Project to minimize diversion of young striped bass from the Delta during May and June reduce project exports, permittee, the United States Bureau of Reclamation, shall be allowed through coordinated operations to make up such deficiencies during later period of the year by direct diversion or by rediversion of releases of stored water through State Water Project facilities.

the cost of associated pumping energy at Banks at the then current value of energy to the SWP. For accounting purposes all Condition 3 water shall be deemed to have been pumped at Banks at a rate of 297 KWH/AF. This rate is based on the rated efficiency of the pumping plant. Any change in the rated efficiency of the pumping plant will result in a correlative change in this KWH/AF rate at Banks.

The CVP shall have the option to convey all Condition 3 water through SWP facilities during July and August. However, it is recognized that the value of energy is time dependent. Therefore, it is likely that the value of energy to pump an amount of water in May and June will be different than the value for pumping an equal amount of water at other times of the year. Prior to April 1 of each year operators of the SWP shall estimate the value of off-peak and on-peak energy for each week of the following twelve months. Prior to April 20 the CVP operators in coordination with the SWP operators shall determine how much CVP energy can be provided for SWP pumping during the May-June period. In the event that the account balance is insufficient to purchase the necessary energy for pumping all Condition 3 water, the CVP may provide and SWP will accept additional energy needed to effect full recovery of Condition 3 water. In the event that the entire quantity of Condition 3 water is received by the CVP prior to the depletion of the account, the SWP shall credit the CVP with energy for additional pumping at Banks Pumping Plant or any joint CVP-SWP pumping facility until the account reaches a zero balance each year.

EXHIBIT E

WATER SHORTAGE AND APPORTIONMENT

1. (a) In its operation of the Central Valley Project (CVP), the United States will use all reasonable means to guard against a condition of shortage in the quantity of water available to the State pursuant to this contract. Nevertheless, if a shortage does occur during any year because of drought, or other causes which, in the opinion of the Contracting Officer, are beyond the control of the United States, no liability shall accrue against the United States or any of its officers, agents, or employees for any damage, direct or indirect, arising therefrom.

(b) In any year that the Contracting Officer determines there is a shortage in the quantity of water available to customers of the United States from the CVP, the Contracting Officer will apportion available water among the water users capable of receiving water from the same CVP facilities by reducing deliveries to all such water users by the same percentage, unless he is prohibited by existing contracts, CVP authorizations, or he determines that some other method of apportionment is required to prevent undue hardship. In the event reduced deliveries are necessary, the water supplies for both municipal and industrial use, and agricultural use shall be reduced by the same percentage for each contractor.

(c) If operation of the CVP to meet legally required Delta water quality control standards, including Federally adopted water quality standards, causes a shortage in water supply and requires a reduction in deliveries of water to the State under this agreement, such reductions will be made in accordance with subdivision (b) of this exhibit and shall not be deemed a breach hereof.

Ninety-ninth Congress of the United States of America
AT THE SECOND SESSION

Begun and held at the City of Washington on Tuesday,
the twenty-first day of January, one thousand nine hundred and eighty-six

An Act

To implement the Coordinated Operations Agreement, the Suisun Marsh Preservation Agreement, and to amend the Small Reclamation Projects Act of 1956, as amended, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

TITLE I--COORDINATED OPERATIONS

Project Operation Policy

Sec. 101. Section 2 of the Act of August 26, 1937 (50 Stat. 850) is amended by--

- (a) inserting at the beginning "(a)"; and
- (b) inserting the following new subsection:

"(b)(1) Unless the Secretary of the Interior determines that operation of the Central Valley project in conformity with State water quality standards for the San Francisco Bay/Sacramento-San Joaquin Delta and Estuary is not consistent with the congressional directives applicable to the project, the Secretary is authorized and directed to operate the project, in conjunction with the State of California water project, in conformity with such standards. Should the Secretary of the Interior so determine, then the Secretary shall promptly request the Attorney General to bring an action in the court of proper jurisdiction for the purposes of determining the applicability of such standards to the project.

"(2) The Secretary is further directed to operate the Central Valley project, in conjunction with the State water project, so that water supplied at the intake of the Contra Costa Canal is of a quality equal to the water quality standards contained in the Water Right Decision 1485 of the State of California Water Resources Control Board, dated August 16, 1978, except under drought emergency water conditions pursuant to a declaration by the Governor of California. Nothing in the previous sentence shall authorize or require the relocation of the Contra Costa Canal intake."

Reimbursable Costs

Sec. 102 Section 2 of the Act of August 26, 1937 (50 Stat. 850) is amended by inserting the following new subsection:

"(c)(1) The costs associated with providing Central Valley project water supplies for the purpose of salinity control and for complying with State water quality standards identified in exhibit A of the 'Agreement Between the United States of America and the Department of Water Resources of the State of California for Coordinated Operation of the Central Valley Project and the State Water Project' dated May 20, 1985, shall be allocated among the project purposes and shall be reimbursed in accordance with existing Reclamation law and policy. The costs of providing water for salinity control and for complying with State water quality standards above those standards identified in the previous sentence shall be nonreimbursable.

"(2) The Secretary of the Interior is authorized and directed to undertake a cost allocation study of the Central Valley project, including the provisions of this Act, and to implement such allocations no later than January 1, 1988."

Coordinated Operations Agreement

Sec. 103. Section 2 of the Act of August 26, 1937 (50 Stat. 850) is amended by inserting the following new subsection:

"(d) The Secretary of the Interior is authorized and directed to execute and implement the 'Agreement Between the United States of America and the Department of Water Resources of the State of California for Coordinated Operation of the Central Valley Project and the State Water Project' dated May 20, 1985: Provided, That--

"(1) the contract with the State of California referred to in subarticle 10(h)(1) of the agreement referred to in this subsection for the conveyance and purchase of Central Valley project water shall become final only after an Act of Congress approving the execution of the contract by the Secretary of the Interior; and,

"(2) the termination provisions of the agreement referred to in this subsection may only be exercised if the Secretary of the Interior or the State of California submits a report to Congress and sixty calendar days have elapsed (which sixty days, however, shall not include days on which either the House of Representatives or the Senate is not in session because of an adjournment of more than three days to a day certain) from the date on which said report has been submitted to the Speaker of the House of Representatives and the President of the Senate for reference to the Committee on Interior and Insular Affairs of the House of Representatives and the Committee on Energy and Natural Resources of the Senate. The report must outline the reasons for terminating the agreement and, in the case of the report by the Secretary of the Interior, include the views of the Administrator of the Environmental Protection Agency and the Governor of the State of California on the Secretary's decision."

Refuge Water Supply Investigation

Sec. 104. The Secretary of the Interior shall not contract for the delivery of more than 75 percent of the firm annual yield of the Central Valley project not currently committed under long-term contracts until one year after the Secretary has transmitted to the Congress a feasibility report, together with his recommendations, on the "Refuge Water Supply Investigations, Central Valley Basin, California."

Adjustment of Rates and Ability to Pay

Sec. 105. The Secretary of the Interior shall include in all new or amended contracts for the delivery of water from the Central Valley project a provision providing for the automatic adjustment of rates by the Secretary of the Interior if it is found that the rate in effect may not be adequate to recover the appropriate share of the existing Federal investment in the project by the year 2030. The contracts shall also include a provision authorizing the Secretary of the Interior to adjust determinations of ability to pay every five years.

Operation and Maintenance Deficits

Sec. 106. The Secretary of the Interior shall include in each new or amended contract for the delivery of water from the Central Valley project provisions ensuring that any annual deficit (outstanding or hereafter arising) incurred by a Central Valley project water contractor in the payment of operation and maintenance costs of the Central Valley project is repaid by such contractor under the terms of such new or amended contract, together with interest on any such deficit which arises on or after October 1, 1985, at a rate equal to the average market yields on outstanding marketable obligations of the United States with remaining periods to maturity comparable to the applicable reimbursement period of the project, adjusted to the nearest one-eighth of 1 percent.

TITLE II--SUISUN MARSH PRESERVATION AGREEMENT

Authority to Enter Agreement

Sec. 201. The Secretary of the Interior is authorized to execute and implement the agreement between the Department of the Interior, the State of California and the Suisun Resources Conservation District (dated November 1, 1985).

Cost-Sharing Provisions

Sec. 202. The costs of implementing the agreement provided in section 201 of this title shall be shared by the Bureau of Reclamation and the California Department of Water Resources in strict accordance with article 12 of that agreement: Provided, That--

(a) payments made by the Secretary of the Interior shall not exceed 40 percent of the construction costs incurred under articles 6, 7, and 8 of the agreement, or \$50,000,000, whichever is less, plus or minus such amounts as are justified by reason of ordinary fluctuations in construction costs as indicated by engineering cost indices applicable to the types of construction involved therein;

(b) the Federal share of continuing annual operation and maintenance costs, including monitoring, shall not exceed 40 percent of the actual operation and maintenance costs; and,

(c) the costs incurred by the United States for construction and for annual operation and maintenance in connection with the implementation of said agreement shall constitute an integral part of the cost of the Central Valley project. The Secretary shall allocate such costs to the reimbursable and nonreimbursable purposes served by the project.

Costs Incurred

Sec. 203. Costs incurred both before and after the date of execution of the agreement herein authorized are to be included in the total for determining the Federal share of construction, operation, and maintenance costs.

Authorization of Appropriations

Sec. 204. There are authorized to be appropriated for the implementation of the agreement referred to in Section 201 of this title \$50,000,000 plus or minus such amounts, if any, as may be justified by reason of ordinary fluctuations in construction costs as indicated by engineering cost indices applicable to the types of construction involved therein and, in addition thereto, in accordance with subsection 201(b) of this title, such sums as may be required for operation and maintenance: Provided, That no Federal funds may be expended pursuant to this title in advance of appropriations therefor: Provided further, That appropriations pursuant to this title shall remain available until expended without any fiscal year limitation.

TITLE III--SMALL RECLAMATION PROJECTS ACT

Reference to Small Projects Act

Sec. 301. As used in this title, the term "the Act" means the Small Reclamation Projects Act of 1956, as amended (43 U.S.C. 422a et seq.).

Rehabilitation and Betterment

Sec. 302. Section 1 of the Act is amended by inserting after the word "laws", with emphasis on rehabilitation and betterment of existing projects for purposes of significant conservation of water, energy and the environment and for purpose of water quality control,".

Filing Fee

Sec. 303. The second sentence of section 3 of the Act is amended by striking "\$1,000" and inserting in lieu thereof "\$5,000".

Cost Sharing

Sec. 304. (a) Section 4(b) of the Act is amended by inserting "(1)" after (b) and by striking "by loan and grant under this Act" and inserting in lieu thereof "by loan and grant of Federal funds".

(b) Section 4(b) of the Act is amended by adding the following new paragraph at the end thereof:

"(2) The Secretary shall require each organization to contribute toward the cost of the project (other than by loan and/or grant of Federal funds) an amount equal to 25 percent or more of the allowable estimated cost of the project: Provided, That the Secretary, at his discretion, may reduce the amount of such contribution to the extent that he determines that the organization is unable to secure financing from other sources under reasonable terms and conditions, and shall include letters from lenders or other written evidence in support of any funding of an applicant's inability to secure such financing in any project proposal transmitted to the Congress: Provided further, That under no circumstances shall the Secretary reduce the amount of such contribution to less than 10 percent of the allowable estimated total project costs. In determining the amount of the contribution as required by this paragraph, the Secretary shall credit toward that amount the cost of investigations, surveys, engineering, and other services necessary to the preparation of proposals and plans for the project as required by the Secretary, and the costs of lands and rights-of-way required for the project, and the \$5,000 fee described in section 3 of this Act. In determining the allowable estimated cost of the project, the Secretary shall not include the amount of grants accorded to the organization under section 5(b).".

Soil Survey

Sec. 305. Section 4(c) of the Act is amended by inserting the following after the first sentence: "Each project proposal transmitted by the Secretary to the Congress shall include a certification by the Secretary that an adequate soil survey and land classification has been made, or that the successful irrigability of those lands and their susceptibility to sustained production of agricultural crops by means of irrigation has been demonstrated in practice. Such proposal shall also include an investigation of soil characteristics which might result in toxic or hazardous irrigation return flows.".

Compatibility with Crops Projects

Sec. 306. Section 5(b) of the Act is amended by striking everything after the words "joint use facilities properly allocable to fish and wildlife enhancement or public recreation;" and substituting the following in lieu thereof:

"(5) that portion of the estimated cost of construction the project which, if it were constructed as a Federal reclamation project, would be properly allocable to functions, other than recreation and fish and wildlife enhancement and flood control, which are nonreimbursable under general provisions of law applicable to such projects; and (6) that portion of the estimated cost of constructing the project which is allocable to flood control and which would be nonreimbursable under general provisions of law applicable to projects constructed by the Secretary of the Army.".

Repayment and Interest

Sec. 307. (a) Section 5(c)(1) of the Act is amended by striking "fifty" and inserting in lieu thereof "forty".

(b) Section 5(c)(2) of the Act is amended to read as follows: "interest, as determined by the Secretary of the Treasury, as of the beginning of the fiscal year in which the contract is executed, on the basis of the average market yields on outstanding marketable obligations of the United States with remaining periods of maturity comparable to the applicable reimbursement period of the project, adjusted to the nearest one-eighth of 1 percent on the unamortized balance of any portion of the loan--

"(A) which is attributable to furnishing irrigation benefits in each particular year to land held in private ownership by a qualified recipient or by a limited recipient, as such terms are defined in section 202 of the Reclamation Reform Act of 1982, in excess of three hundred and twenty irrigable acres; or,

"(B) which is allocated to domestic, industrial, or municipal water supply, commercial power, fish and wildlife enhancement, or public recreation except that portion of such allocation attributable to furnishing benefits to a facility operated by an agency of the United States, which portion shall bear no interest."

(c) The remainder of section 5(c) of the Act is stricken in its entirety.

Fish and Wildlife Funding

Sec. 308. Section 8 of the Act is amended by adding at the end thereof the following sentence: "The Secretary shall transfer to the Fish and Wildlife Service or to the National Marine Fisheries Service, out of appropriations or other funds made available under this Act, such funds as may be necessary to conduct the investigations required to carry out the purposes of this section."

Authorization and Limitation

Sec. 309. (a) Section 10 of the Act is amended in the first sentence by inserting before ": Provided" "and, effective October 1, 1986, not to exceed an additional \$600,000,000".

(b) Section 10 of the Act is further amended by adding at the end thereof the following: "Not more than 20 percent of the total amount of additional funds authorized to be appropriated effective October 1, 1986, for loans and grants pursuant to this Act shall be for projects in any single State: Provided, That beginning five years after the date of enactment of this Act, the Secretary is authorized to waive the 20 percent limitation for loans and grants which meet the purposes set forth in section 1 of this Act: Provided further, That the decision of the Secretary to waive the limitation shall be submitted to the Congress together with the project proposal pursuant to section 4(c) of this Act and shall become effective only if the Congress has not, within 60 legislative days, passed a joint resolution of disapproval for such a waiver."

Transition Rules

Sec. 310. The provisions of Sections 303 and 308 of this title shall take effect upon enactment of this title. The provisions of sections 304(a) and 305 of this title shall be applicable to all proposals for which final applications are received by the Secretary after January 1, 1986. The provisions of Sections 302, 304(b), 306, and 307 shall be applicable to all proposals for which draft applications are received by the Secretary after August 15, 1986.

Surplus Crops Report

Sec. 311. The Secretary of the Interior and the Secretary of Agriculture shall review the effect of the Small Reclamation Projects Act of 1956, as amended, on the operation and objectives of the programs of the Department of Agriculture dealing with the production of surplus commodities as determined by the Secretary of Agriculture pursuant to the Agriculture Act of 1949, as amended, and shall jointly submit a report of their findings to the Committee on Energy and Natural Resources and the Committee on Agriculture, Nutrition and Forestry of the Senate and the Committee on Interior and Insular Affairs and the Committee on Agriculture of the House of Representatives no later than 120 days from the date of enactment of this Act together with their recommendations, if any, for any changes to either or both programs to better achieve the objectives of such programs.

TITLE IV--VALIDATION OF CONTRACTS

Sec. 401. The Federal Power Act (Act of June 10, 1920, 41 Stat. 1063; 16 U.S.C. 791a et seq., and Acts amendatory thereof and supplementary thereto) is amended in section 10(e) (16 U.S.C. 803(e)) by deleting "Commission." and inserting in lieu thereof: "Commission: Provided however, That no charge shall be assessed for the use of any Government dam or structure by any licensee if, before January 1, 1985, the Secretary of the Interior has entered into a contract with such licensee that meets each of the following requirements:

"(A) The contract covers one or more projects for which a license was issued by the Commission before January 1, 1985.

"(B) The contract contains provisions specifically providing each of the following:

"(i) A powerplant may be built by the licensee utilizing irrigation facilities constructed by the United States.

"(ii) The powerplant shall remain in the exclusive control, possession, and ownership of the licensee concerned.

"(iii) All revenue from the powerplant and from the use, sale, or disposal of electric energy from the powerplant shall be, and remain, the property of such licensee.

"(C) The contract is an amendatory, supplemental and replacement contract between the United States and: (i) the Quincy-Columbia Basin Irrigation District (Contract No. 14-06-100-6418); (ii) the East Columbia Basin Irrigation District (Contract No. 14-06-100-6419); or, (iii) the South Columbia Basin Irrigation District (Contract No. 14-06-100-6420).

This paragraph shall apply to any project covered by a contract referred to in this paragraph only during the term of such contract unless otherwise provided by subsequent Act of Congress."

North-of-the-Delta Offstream Storage Investigation

2013 Progress Report



U.S. Department of the Interior
Bureau of Reclamation
Mid-Pacific Region
Sacramento, California

December 2013

EXECUTIVE SUMMARY

Introduction

The purpose of this Progress Report is to present results to date of the North-of-the-Delta Offstream Storage (NODOS) feasibility studies that are underway by the United States (U.S.) Department of the Interior, Bureau of Reclamation (Reclamation) and State of California Department of Water Resources (DWR) to evaluate the potential benefits of new storage north of the Sacramento and San Joaquin River Delta (Delta) (Figure ES 1). New offstream storage offers the potential to improve the flexibility of the federal Central Valley Project (CVP) and State Water Project (SWP) systems to ensure these systems continue to contribute to the water supply and reliability, water quality, and environmental needs of California and the nation.

Reclamation and DWR are sharing in the costs of the studies and interruptions in state funding have delayed the completion of the feasibility studies. This report responds to the immediate congressional and state interest in the results to date.

The NODOS feasibility studies are being conducted consistent with the 1983 U.S. Water Resources Council (WRC) *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (P&Gs) (WRC, 1983).

Study Authorization

Public Law 108-7 states “The Secretary of the Interior, in carrying out CALFED Bay-Delta Program (CALFED)-related activities, may undertake feasibility studies for Sites Reservoir, Los Vaqueros Reservoir Enlargement, and Upper San Joaquin Storage projects. These storage studies should be pursued along with ongoing environmental and other projects in a balanced manner.” Public Law 108-361 authorized project-specific “planning and feasibility studies” for both surface and groundwater storage, including Sites Reservoir in Colusa County.

DWR received authorization to study NODOS beginning in 1996 under State of California Proposition 204, The Safe, Clean, Reliable Water Supply Act, which was approved in 1996 and provided funding for feasibility and environmental investigations of offstream storage projects upstream from the Delta.

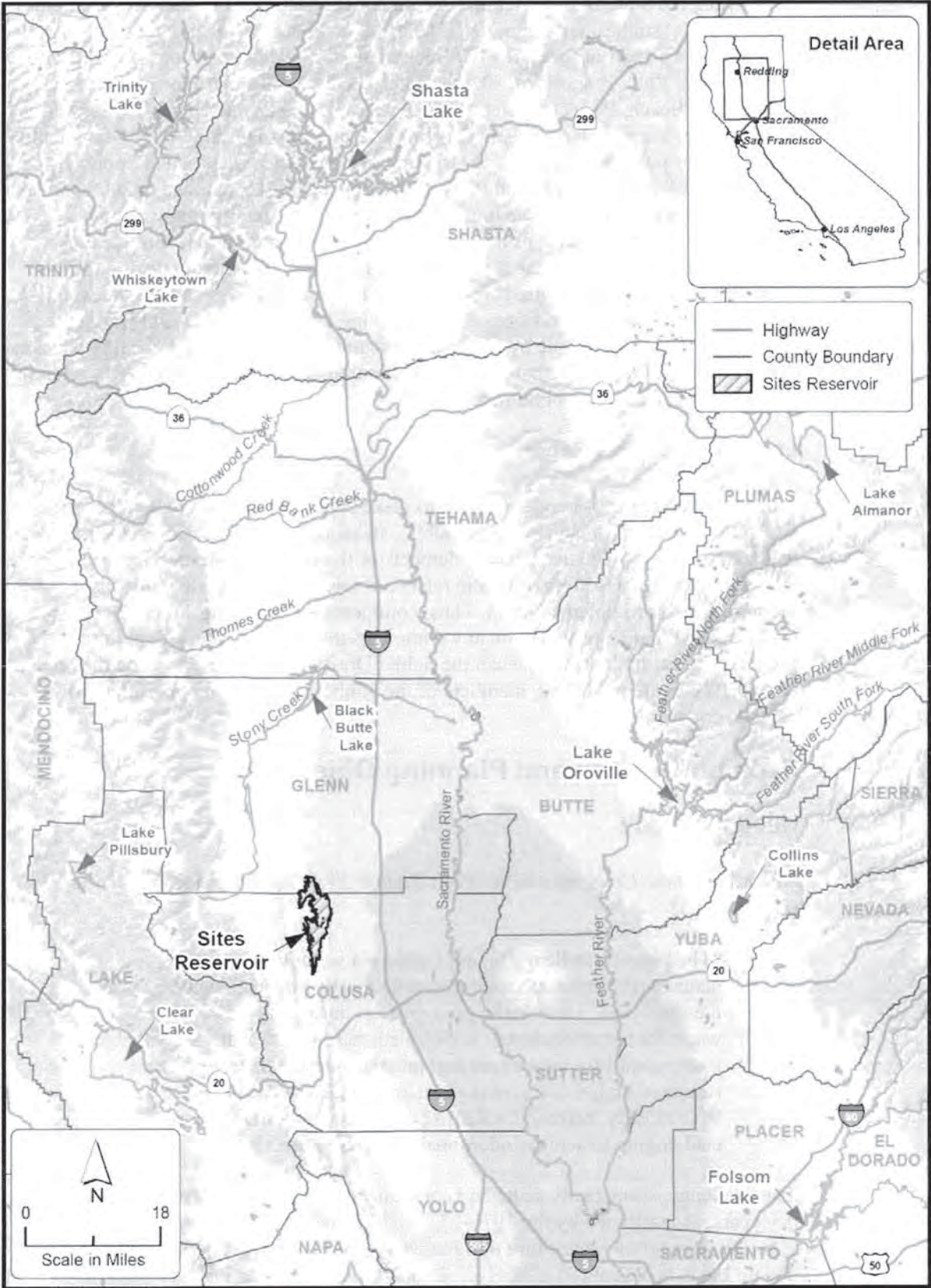


Figure ES-1. Setting for NODOS Feasibility Studies

In addition, the State Budget Act of 1998 authorized DWR to continue feasibility and environmental studies pertaining to the NODOS and alternatives. Subsequent funding was allocated as part of the CALFED Integrated Storage Investigations Program and in November 2002, Proposition 50, the Water Security, Clean Drinking Water, Coastal and Beach, Protection Act of 2002, was approved, authorizing funding for surface water storage planning and feasibility studies pursuant to CALFED. State of California Proposition 84, The Safe Drinking Water, Water Quality and Supply, Flood Control, River and Coastal Protection Act of 2006, as amended in 2009 and 2012, were approved to provide funding to: ensure that safe drinking water is available to all Californians; protect public from catastrophic floods; protect the rivers, lakes and streams of the state from pollution, loss of water quality, and destruction of fish and wildlife habitat; protect the beaches, bays and coastal waters of the state for future generations; and revitalizing our communities and making them more sustainable and livable by investing in sound land use planning, local parks, and urban greening. NODOS feasibility studies funding is provided from DWR's general fund and from California bond funds.

Limitations of This Report

This Progress Report is being provided to make current information about potential NODOS alternatives available to the public, stakeholders, and decision makers. The lead agencies recognize that several elements of the feasibility studies are incomplete and, thus, not ready for formal public release at this time and no alternative is recommended for implementation. Thus, comments are not being solicited and responses will not be provided on any comments that may be received on this progress report. In the future, when the public Draft Feasibility Report and the related Draft EIR/EIS are published, members of the public will have an opportunity to provide comments.

Project Purpose and Planning Objectives

Need for Study

According to the *California Water Plan Update 2005: A Framework for Action* (DWR, 2005)

“The biggest challenge facing California water resources management remains making sure that water is in the right places at the right time. This challenge is greatest during dry years: When water for the environment is curtailed sharply, less water is available from rainfall for agriculture and greater reliance on groundwater results in higher costs for many users. In the meantime, those who have already increased water use efficiency may find it more challenging to achieve additional water use reductions.”

The challenge is especially acute and consequences are exacerbated during multiple dry years, as evidenced by the 1976-77, 1987-92, and 2007-09 droughts. In 2009, the U.S. Department of Agriculture designated all counties within the San Joaquin River, Tulare Lake, and Central Coast Hydrologic Regions as either Primary Natural Disaster Areas (21 counties) or Natural Disaster Areas (29 counties) because of losses caused by drought.

This lack of water supply reliability is closely linked to a decrease in the flexibility of the operations for the CVP and SWP. The flexibility of the CVP and SWP system has become increasingly constrained by competing demands for water. This trend of increasing constraints threatens the ability of the system to meet water use needs while protecting ecosystems and water quality. The flexibility and adaptive capability of these systems was significant when the projects were first implemented. However, flexibility has diminished over time due to population growth and the recognition of the need for additional environmental water commitments. Additional impacts to flexibility are foreseen as a result of increasing population and potential climate change effects.

As a result of considerations like these, the Preferred Program Alternative in the CALFED Bay-Delta Programmatic Record of Decision (CALFED ROD) identified a need for up to 6 million acre-feet (MAF) of new storage in California, including up to 3 MAF of storage north of the Delta. This report focuses on problems and opportunities for fulfilling part of the recommended 3 MAF of storage north-of-the-Delta.

Purpose Statement for Feasibility Studies

The purpose of the NODOS feasibility studies is to evaluate new offstream surface storage located north of the Delta, consistent with the following planning objectives and constraints.

Improve Water Supply and Water Supply Reliability (Primary Objective)

The NODOS feasibility studies focus on the use of offstream storage to provide increased water supply and improve reliability of water deliveries for municipal, industrial, agricultural, and environmental uses. Water from NODOS can also serve as an alternate source of water to meet the incremental Level 4 refuge supply demands established in the Central Valley Project Improvement Act for maintenance of wildlife refuges. A new offstream reservoir could also supply water in the event of levee failures in the Delta to reduce the effect of highly saline water surging into the Delta.

Increase Populations of Anadromous Fish and Other Aquatic Species (Primary Objective)

Several environmental factors have negatively affected the populations of anadromous fish and other aquatic species in the Sacramento River watershed and throughout the Delta. New offstream storage north of the Delta could benefit anadromous fish and other aquatic species by:

- Improving the reliability of cold-water carry-over storage in Shasta Lake, Lake Oroville, Trinity Lake, and Folsom Lake.
- Providing more frequent releases from Shasta Dam of water with appropriate temperatures to benefit all species and life stages of anadromous salmonids between Keswick Dam and Red Bluff.

- Increasing the availability of coldwater pool storage at Folsom Dam to provide Reclamation with increased operational flexibility to provide suitable water temperatures in the Lower American River.
- Stabilizing fall flows in the Sacramento River between Keswick Dam and Red Bluff Diversion Dam (RBDD) to minimize dewatering of fall-run Chinook salmon redds.
- Providing increased flows from spring through fall in the lower Sacramento River by changing the seasonal pattern of diversions at Red Bluff to the Tehama-Colusa (T-C) Canal and at Hamilton City to the Glenn-Colusa Irrigation District (GCID) Canal.
- Stabilizing flows in the lower American River to minimize the stranding of fall-run Chinook salmon redds and steelhead redds.
- Providing supplemental Delta outflow during summer and fall months to increase estuarine habitat and improve food availability for anadromous fishes and other estuarine-dependent species. This additional seasonal outflow would result in a more favorable position for X2. (X2 is a Delta management tool, and defined as the distance in kilometers from the Golden Gate Bridge to the locations where the tidally averaged near-bottom salinity in the Delta measures 2 parts per thousand.)

Provide Sustainable Hydropower Generation (Primary Objective)

Hydropower generated at offstream reservoirs can play an important role in development of renewable energy with reduced greenhouse gas emissions. Equipping an offstream reservoir with pumped storage capability facilitates the integration of other forms of renewable energy into the power grid. The project could produce electricity to supply high-peak demands and pump water into the reservoir during periods of low demand when the energy cost is reduced.

Improve Water Quality (Primary Objective)

Agricultural runoff, acid mine drainage, treated wastewater discharges, and urban runoff all affect water quality in the lower Sacramento River. The Sacramento River from RBDD downstream to Knights Landing is listed as an impaired water body by the State Water Resources Control Board.

Improved water quality in the Delta is needed for drinking water, agriculture, and environmental restoration. The Delta system is the diversion point for drinking water for 25 million Californians, and it is critical to California's agricultural economy. NODOS could improve water quality by providing increased flows of high-quality water during periods when water quality is impaired.

Provide Opportunities for Recreation (Secondary Objective)

The planning of any reservoir north of the Delta provides an opportunity to develop new recreational facilities. Recreation in the immediate vicinity of a new reservoir would include hiking, fishing, camping, boating, and mountain biking.

Provide Flood Damage Reduction (Secondary Objective)

The NODOS Project would provide an opportunity to reduce flooding in local watersheds.

Public Involvement and Outreach

A wide range of public involvement activities have been performed in support of the NODOS feasibility studies. These activities enrich the planning process and meet the requirements of the National Environmental Policy Act (NEPA), Executive Order 12898 (Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations), and Presidential memorandum regarding the engagement of federally recognized tribal governments.

Formal scoping was performed from November 2001 to February 2002 and a variety of briefings and tours have been provided periodically to agencies, groups, and individuals who have expressed interest in the project.

The Notice of Preparation (NOP) was filed with the State Clearinghouse, and on November 9, 2001, the federal Notice of Intent (NOI) was published in the Federal Register to inform the public about the feasibility studies and environmental documentation process, consistent with the California Environmental Quality Act and NEPA. The formal scoping process for the NODOS feasibility studies began with the publication of the NOP and NOI and concluded on February 8, 2002. During the 2001-2002 scoping period, one tribal and three public scoping meetings were held. The study team received 57 comments that addressed program alternatives. Some comments were specific suggestions related to the types or range of alternatives, such as water-use efficiency, conjunctive use, land fallowing, wastewater reclamation and recycling, and Shasta Lake enlargement. Others discussed more generally about what alternatives should or should not be developed and the possible benefits/impacts of certain alternatives. The Scoping Report (Reclamation and DWR, 2002) includes a complete summary of the comments received during the scoping period.

Additional opportunities for public involvement and outreach will be provided throughout the remaining feasibility studies stages, including but not limited to:

- Draft Feasibility Report and EIR/EIS (rvw, cmp, hearings)
- Final Feasibility Report and EIR/EIS
- ROD/NOD
- Congressional and State Legislation Actions/ Decision Process

Plan Formulation

Table ES-1 summarizes the objectives for NODOS.

Table ES-1. NODOS Planning Objectives Summary

Primary Objectives
Improve Water Supply and Water Supply Reliability
Increase Populations of Anadromous Fish and Other Aquatic Species
Provide Sustainable Hydropower Generation
Improve Water Quality
Secondary Objectives
Provide Opportunities for Recreation
Provide Flood Damage Reduction

For the NODOS feasibility studies, an iterative planning process consistent with the P&Gs and NEPA/California Environmental Quality Act was used, as shown on Figure ES-2. Initially, feasibility studies efforts focused on defining problems, needs, opportunities, planning objectives, and constraints. The initial phase culminated in the release of the *North-of-the-Delta Offstream Storage Investigation Final Initial Alternatives Information Report* in 2006 (Reclamation and DWR, 2006a).

The second phase of the planning process emphasized identification of management measures and developing combinations of these measures to formulate and screen preliminary alternative plans. The second phase culminated with the release of the *North-of-the-Delta Offstream Storage Investigation Plan Formulation Report* (PFR) in 2008 (Reclamation and DWR, 2008).

The ongoing feasibility studies represent the third phase of the investigation and includes further technical, environmental, economic, and financial analyses. The forthcoming draft report will evaluate the technical, environmental, economic, and financial feasibility of NODOS. It is anticipated that these interim documents and the CALFED Program ROD and Programmatic EIR/EIS will be cited and included by reference in the forthcoming Draft Feasibility Report and EIR/EIS for NODOS.

Management Measures. The NODOS feasibility studies consider a number of management measures. Management measures are project actions or features that address a specific planning objective. The management measures retained to support the primary and secondary planning objectives include:

- **Water Supply and Supply Reliability (Primary):** Develop new offstream storage (Colusa Reservoir Complex, Red Bank Project, Sites Reservoir, or Newville Reservoir).
- **Water Supply and Supply Reliability (Primary):** Improve water use efficiency, implement additional recycling, and employ water transfers between users to satisfy unmet demands.

This page intentionally left blank

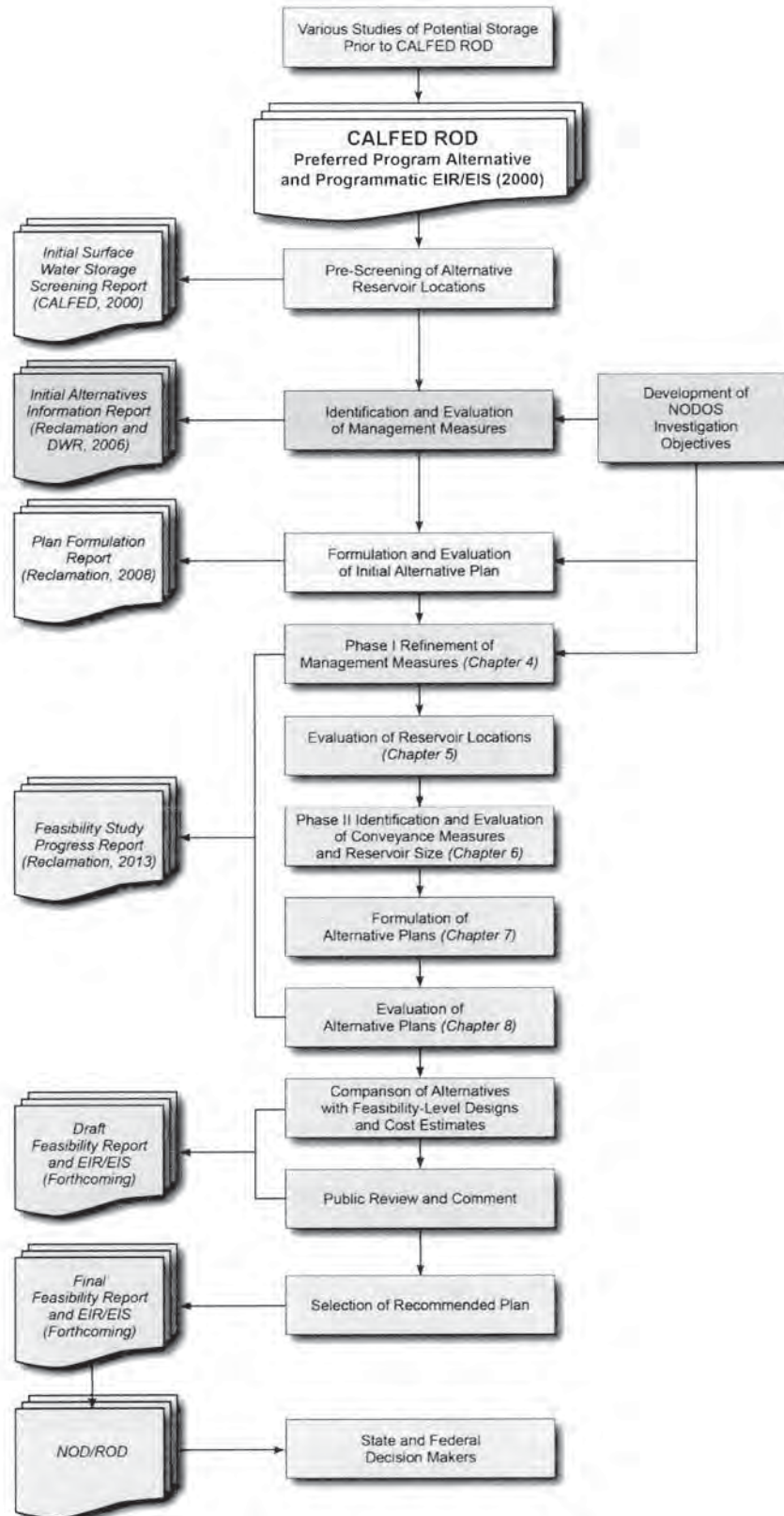


Figure ES-2. Iterative Alternative Formulation Process

This page intentionally left blank

- **Survivability of Anadromous Fish and Other Aquatic Species (Primary):** Improve system flows and temperatures by integrating offstream storage into CVP and SWP system operations.
- **Integrated, Flexible Hydropower Generation (Primary):** Equip offstream reservoir with facilities to enable pump storage operation.
- **Water Quality (Primary):** Increase flows of high-quality water in the lower Sacramento River and Delta through releases from new offstream storage.
- **Recreation (Secondary):** Provide new facilities for recreation adjacent to the new reservoir.
- **Flood Damage Reduction (Secondary):** Provide local flood damage reduction associated with ephemeral streams.

Development of Alternatives

The NODOS feasibility studies consider a wide range of alternatives. The management measures and alternative attributes were evaluated as follows:

- Determining a preferred reservoir location
- Determining the best conveyance system to fill the reservoir and release the water for beneficial uses
- Developing alternatives for the preferred reservoir location and conveyance system to determine the appropriate sizing of the reservoir and the preferred seasonal schedule for operations

These steps are described in further detail in the following sections.

Alternate Reservoir Locations

The geographic scope of analysis for the NODOS feasibility studies was narrowed from the CALFED Program ROD and EIR/EIS (CALFED, 2000a) scope which included an evaluation of 52 potential reservoir locations along with conservation measures and conjunctive use options for the system as a whole. When considering surface water storage, offstream facilities are recommended by CALFED as a way to provide additional storage without creating new barriers to the migration of anadromous fish. The NODOS feasibility studies identified four potential reservoir locations (Red Bank Project, Newville Reservoir, Colusa Reservoir Complex, and Sites Reservoir) located north of the Delta for offstream storage (Figure ES-3).

Evaluation of the four alternative reservoir locations (Table ES-1) determined that the Sites Reservoir location was most capable of meeting the project objectives and satisfies the project purpose for evaluating new offstream storage north-of-the-Delta. Criteria used in this calculation included divertible water supply, total storage, environmental impacts, and approximate cost per acre-foot for storage.

Evaluation of the four alternative reservoir locations (Table ES-2) determined that the Sites Reservoir location was more capable of meeting the project objectives than

Executive Summary

Newville Reservoir or the Red Bank Project, largely because of its closer proximity to the Sacramento River and existing infrastructure (the T-C and GCID canals). Sites Reservoir has lower costs and fewer environmental impacts than the larger Colusa Reservoir Complex.

Table ES-2. Evaluation of Potential Reservoir Locations

Reservoir	Conclusions
Colusa Reservoir	• Approximately 3 MAF of storage • Four times the cost of Sites or Newville, but only a 25 percent increase in yield • Impacts more acreage, greater environmental impact
Newville Reservoir	• Approximately 1.9 MAF of storage • Greater impact to cultural resources • More than double the blue oak, wetland, and riparian acreage impacted than for Sites Reservoir • Fall and late fall runs for salmon and steelhead impacted in Thomes Creek
Red Bank Reservoir Complex	• Approximately 3.5 TAF of storage • Includes on-stream facilities, does not meet project purpose for providing offstream storage • Greater impacts to aquatic resources from introducing barrier to migration • Greatest habitat diversity • Potential for reservoir leakage

Table ES-2. (Continued)

Reservoir	Conclusions
Sites Reservoir	• Approximately 1.8 MAF of storage • Fewer environmental impacts than alternative locations • Cost per acre-foot of water is comparable to Newville Reservoir and much lower than Colusa Reservoir • Existing GCID and TCCA canals significantly reduce construction costs and environmental impacts associated with conveyance • Existing GCID and TCCA canals significantly improve the reliability of reservoir filling operations

GCID = Glenn-Colusa Irrigation District
MAF = million acre-feet

TAF = thousand acre-feet
TCCA = Tehama-Colusa Canal Authority

Alternate Conveyance Systems

An array of 17 conveyance measures for filling and releasing water from Sites Reservoir were identified for consideration and evaluation. Conveyance measures originating from the Sacramento River include the GCID Canal, the T-C Canal, and a new pipeline (called the Delevan Pipeline), as illustrated in Figure ES-4. Tributary source conveyance measures include a new pipeline from the Colusa Basin Drain (CBD) and a new pipeline from Stony Creek originating at the Black Butte afterbay and connecting to the T-C Canal below the City of Orland.

Table ES-3 shows the conveyance management measures recommended for further consideration based on the initial evaluation of costs, ability to meet water quality objectives, and environmental impacts. Conveyance options that used existing conveyance (T-C and GCID canals) greatly reduced the associated environmental impacts. The ability to release water to the Sacramento River via the Delevan Pipeline was extremely important to achieving the primary objective for water quality improvement and significantly improved the performance with respect to all other primary objectives. Neither the CBD nor Stony Creek were as reliable as a source for filling the reservoir as the Sacramento River.

Table ES-3. Conveyance Measures Recommended for Further Consideration

Conveyance Measure	Size
T-C Canal (existing)	2,100 cfs capacity
GCID Canal (existing)	1,800 cfs capacity
Delevan Pipeline (new)	1,500 cfs capacity 2,000 cfs capacity 3,000 cfs capacity

cfs = cubic feet per second
 GCID = Glenn-Colusa Irrigation District
 T-C = Tehama-Colusa

Preliminary Alternatives

Nine initial alternatives (No Project Alternative and eight action alternatives) were developed to address the primary planning objectives, constraints, and criteria, as addressed in the PFR (Reclamation and DWR, 2008). The initial alternatives were based on different themes that incorporated different levels of accomplishing the primary objectives. The evaluation of the initial alternatives helped determine how changing the operations of the NODOS project affected its performance. An approach that balanced the operations to address each primary objective and enhance the project's benefits was recommended for detailed evaluation.

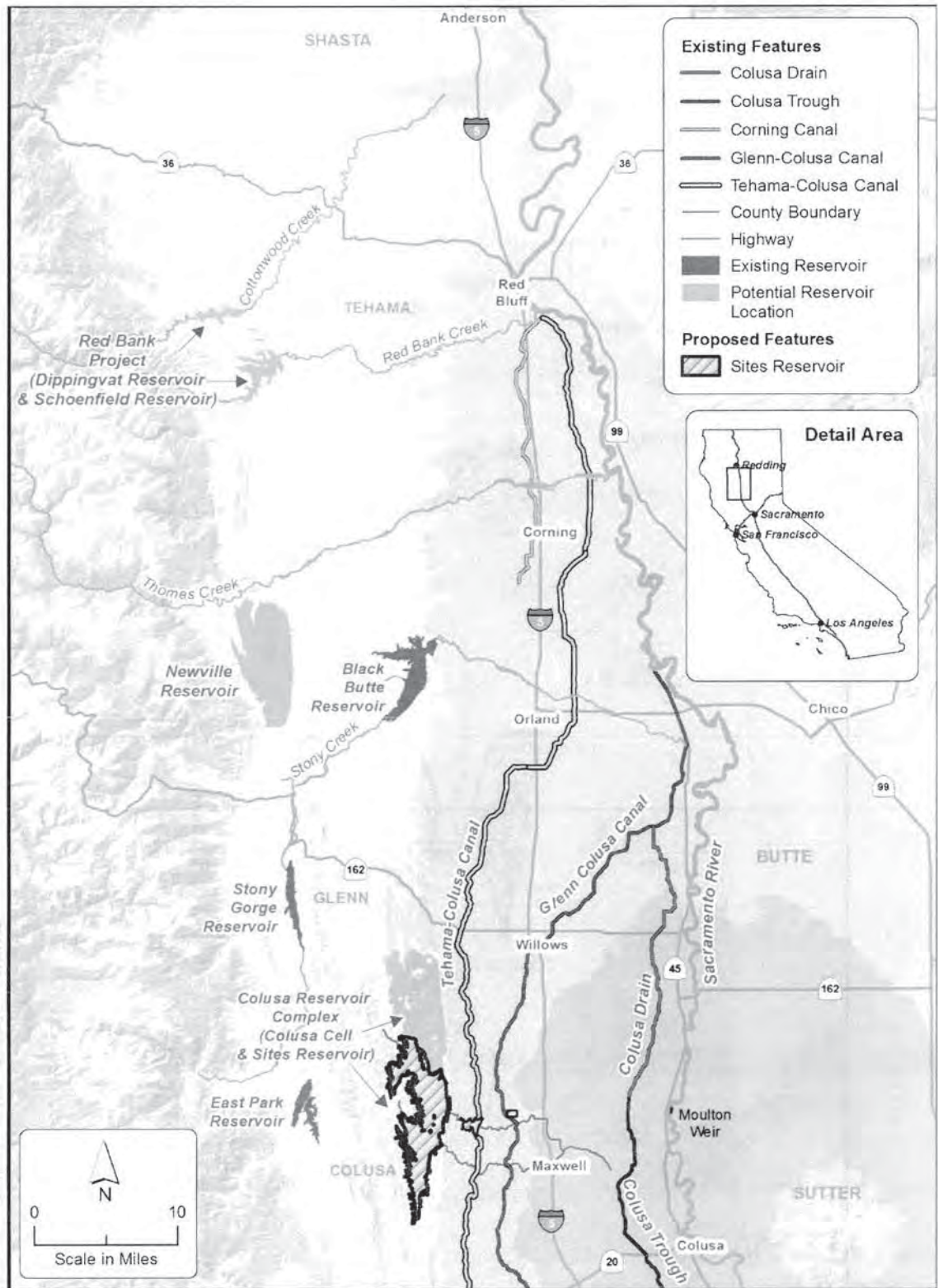


Figure ES-3. Alternative Offstream Locations for NODOS

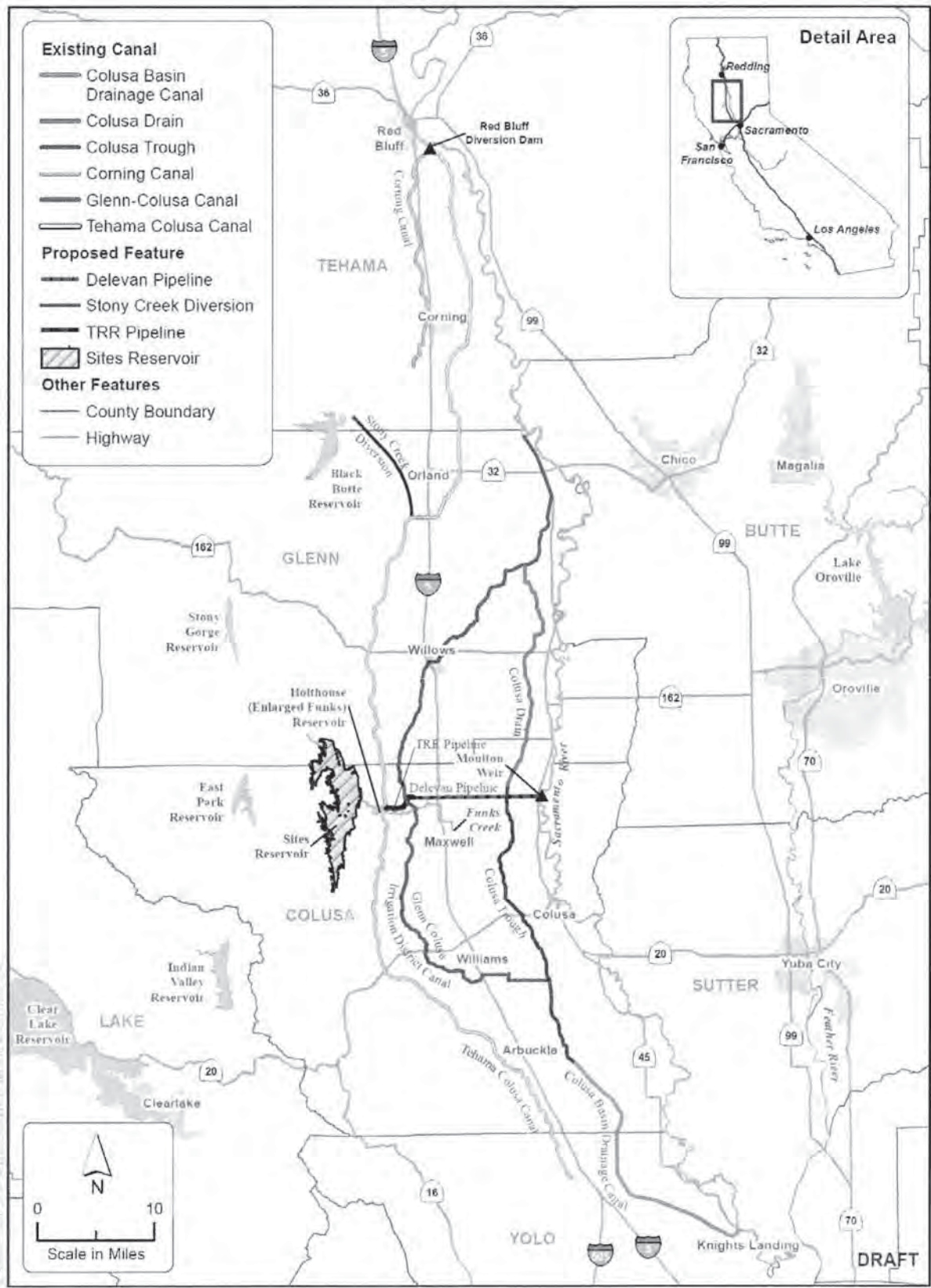


Figure ES-4. NODOS Conveyance Alternatives

No Project Alternative and Alternative Plans

Three plans considered in detail for the forthcoming Draft Feasibility Report and EIR/EIS alternatives and a No Project alternative were developed for detailed evaluation. Each plan addresses, in varying degrees, all of the NODOS planning objectives. The planning horizon for the future conditions is assumed to be 100 years. Each of the alternative plans includes the following measures:

- Developing new offstream storage at Sites Reservoir
- Improving system flows and temperatures by integrating offstream storage into CVP and SWP operations
- Providing an ecosystem enhancement fund to support gravel replenishment, habitat development, and other enhancements in the Sacramento River watershed between the Feather River and Keswick Dam
- Providing pump storage capability to support the integration of hydropower generated at the reservoir with renewable energy opportunities
- Increasing flows of high-quality water in the lower Sacramento River and Delta through releases from Sites Reservoir
- Providing new facilities for recreation adjacent to the new reservoir
- Providing local flood damage reduction associated with ephemeral streams

No Project Alternative: Under the No Project Alternative, reasonably foreseeable actions would be implemented, but new storage north of the Delta would not be developed to improve water supply, enhance the survivability of anadromous fish, improve drinking water quality in the Delta, or improve flexible hydropower generation. Reasonably foreseeable actions include actions that are currently authorized, have secured funding for design and construction, and for which environmental permitting and compliance activities are substantially complete (see Chapter 6). The No Project Alternative provides a basis of comparison for evaluating the potential benefits and effects of the alternative plans.

Small Reservoir with New Diversion (Alternative A): Alternative A includes a 1.27 MAF reservoir (Figure ES-5). The smaller reservoir requires fewer (six) saddle dams, and the two main dams (Sites Dam and Golden Gate Dam) would be smaller. Because the smaller reservoir would have a lower water surface elevation (WSE), less hydropower could be generated at the Sites Pumping/Generating Plant under Alternative A. Water would be conveyed to the reservoir using the existing T-C and GCID canals and through the Delevan Pipeline. The Delevan Pipeline Intake/Discharge Facilities include a new screened intake capable of pumping up 2,000 cubic feet per second (cfs) from the Sacramento River and releasing up to 1,500 cfs back to the river. The Delevan Pipeline Intake/Discharge Facilities also include hydropower generation capability. Alternative A also includes three new recreation areas (two sites for potential future recreation areas are also identified). The operation of Sites Reservoir would be integrated with the operation of the CVP and SWP.

system. Water stored during wet years would increase the reliability of water supply throughout the system during dry years. Water stored in Sites Reservoir would also enable improvements to the coldwater pools for Trinity Lake, Shasta Lake, Lake Oroville, and Folsom Lake. Water released to the Sacramento River through the Delevan Pipeline would provide water quality benefits in the Delta.

Large Reservoir with Existing Diversions (Alternative B): Alternative B provides 1.81 MAF storage capacity (Figure ES-6). The larger reservoir requires more (nine) saddle dams, and the Sites Dam and Golden Gate Dam are larger than they are under Alternative A. The resulting higher surface water elevation supports a higher hydropower generation capacity for the Sites Pumping/Generating Plant. Water would be conveyed to the reservoir using only the T-C and GCID canals. The Delevan Pipeline allows the release of up to 1,500 cfs back to the Sacramento River, but no new intake facility is provided to divert water from the river at this location. As a result, more water would be diverted at the existing facilities near Red Bluff (T-C Canal) and Hamilton City (GCID Canal). With only two diversion points, the reservoir would be more challenging to fill and have a lower average WSE. Also, there is no hydropower generation at the Delevan Pipeline Discharge Facility. Alternative B also includes three new recreation areas (two sites for potential future recreation areas are also identified). The operation of Sites Reservoir would be integrated with the operation of the CVP and SWP system. Water stored during wet years would increase the reliability of water supply throughout the system during dry years. Water stored in Sites Reservoir would also enable improvements to the coldwater pools for Trinity Lake, Shasta Lake, Lake Oroville, and Folsom Lake. Water released to the Sacramento River through the Delevan Pipeline would provide water quality benefits in the Delta.

Large Reservoir with New Diversion (Alternative C): Alternative C provides 1.81 MAF storage capacity. The larger reservoir requires more (nine) saddle dams, and the Sites Dam and Golden Gate Dam are larger than they are in Alternative A (Figure ES-7). The resulting higher surface water elevation supports a higher hydropower generation capacity for the Sites Pumping/Generating Plant. Water would be conveyed to the reservoir using the T-C and GCID canals and the Delevan Pipeline. The Delevan Pipeline Intake/Discharge Facilities include a new screened

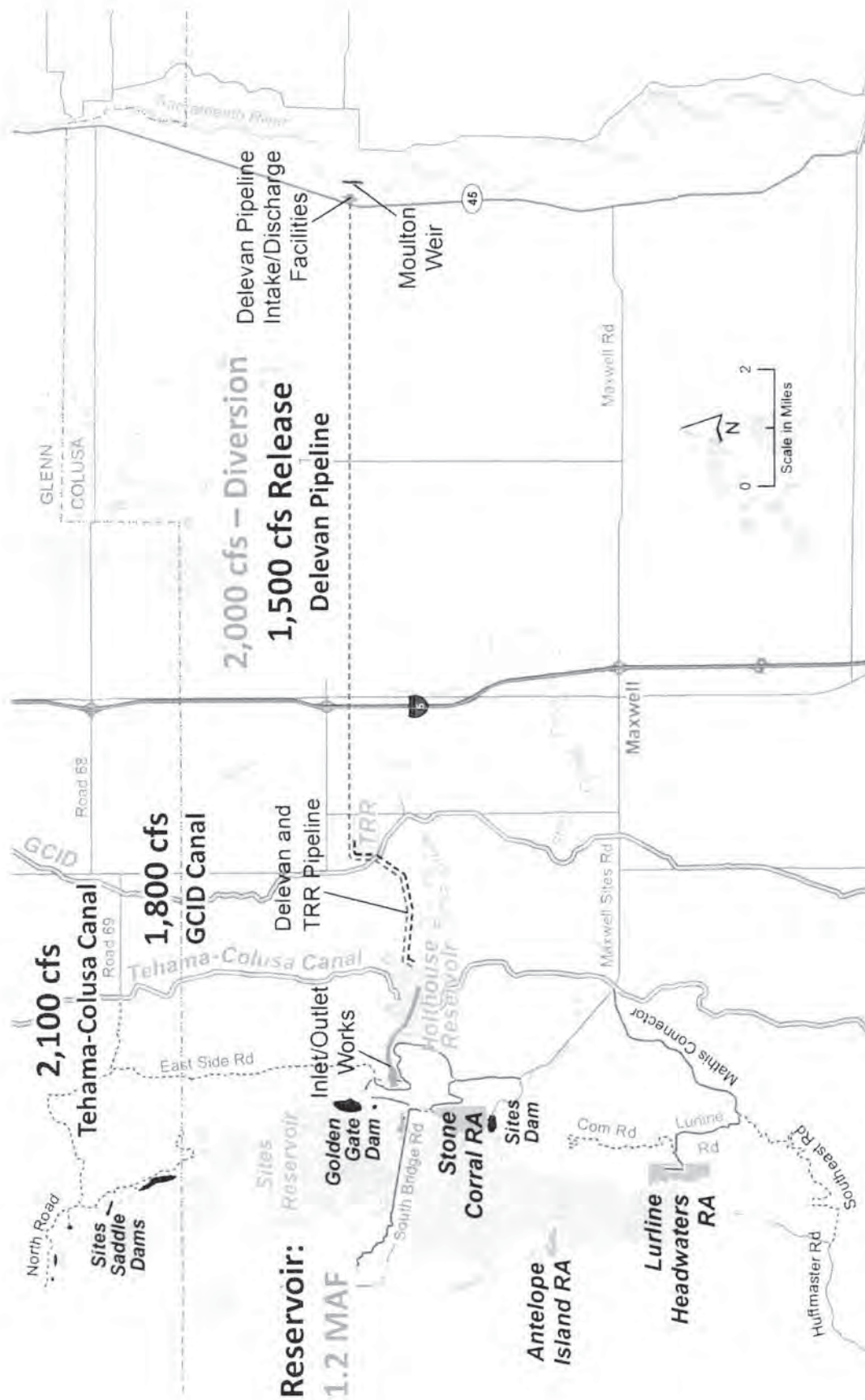


Figure ES-5. Features of NODOS Alternative A

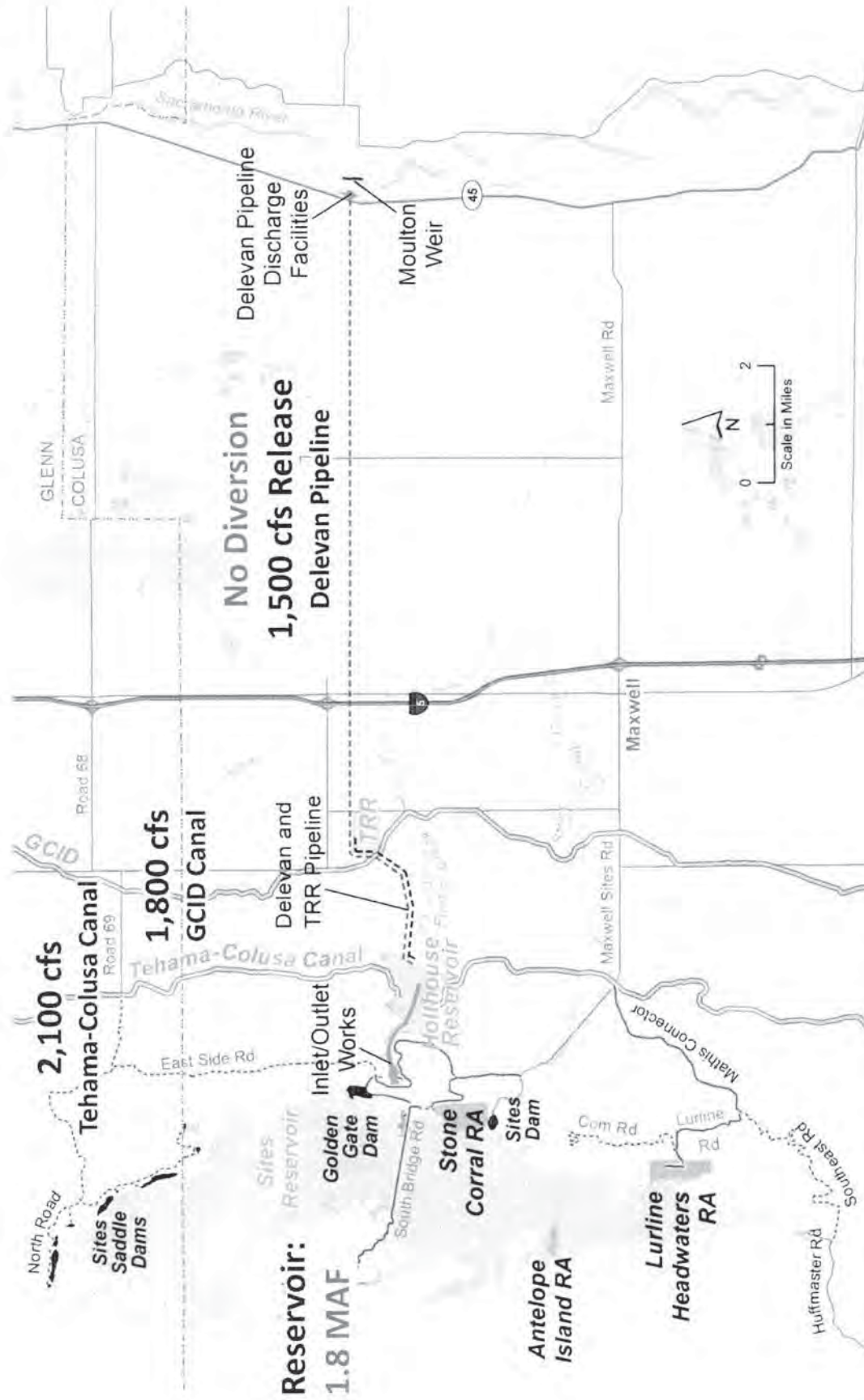


Figure ES-6. Features of NODOS Alternative B

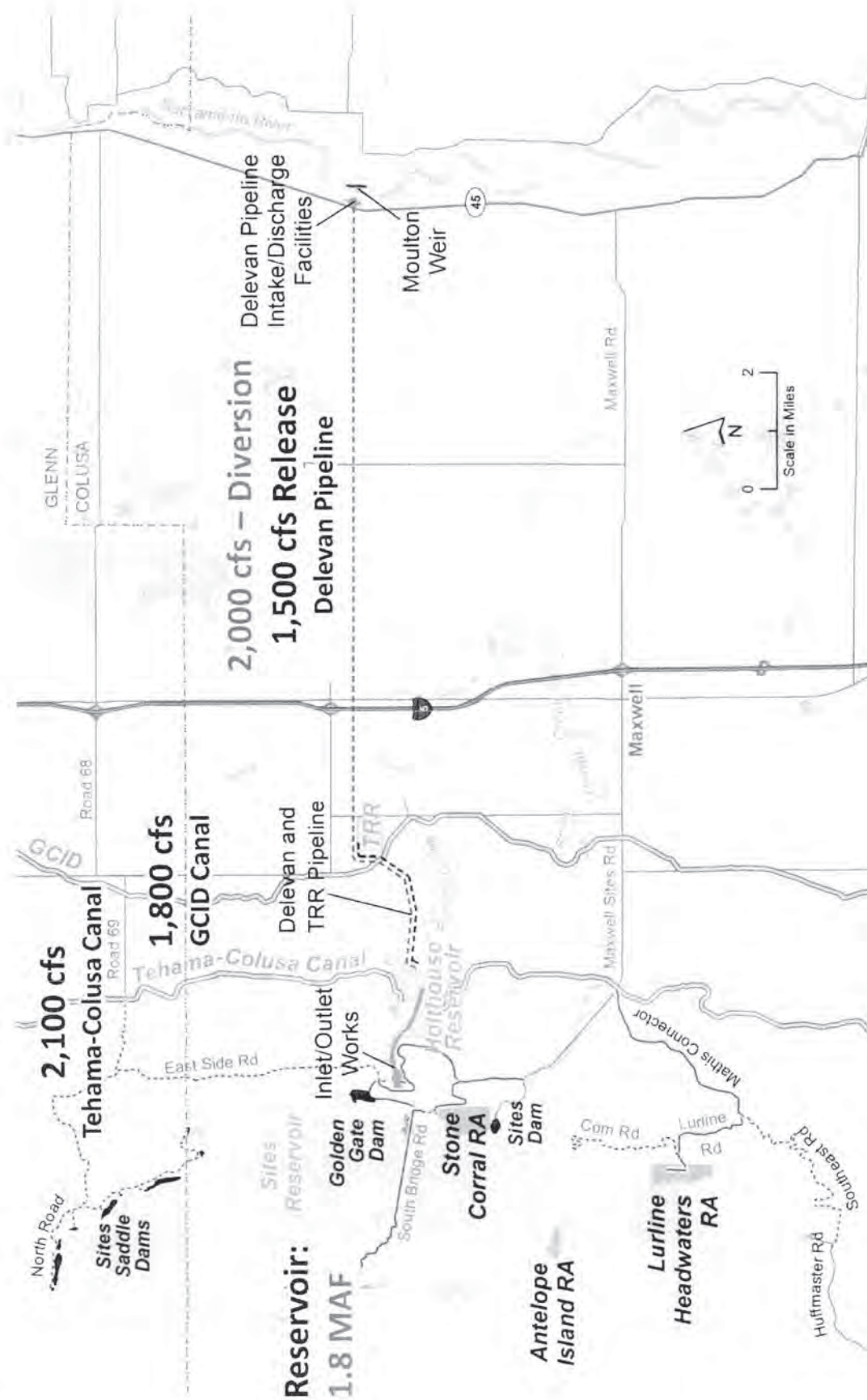


Figure ES-7. Features of NODOS Alternative C

intake capable of pumping up 2,000 cfs from the Sacramento River and releasing up to 1,500 cfs back to the river. The Delevan Pipeline Intake/Discharge Facilities also include hydropower generation capability. Alternative C also includes three new recreation areas (two sites for potential future recreation areas are also identified). The operation of Sites Reservoir would be integrated with the operation of the CVP and SWP system. Water stored during wet years would increase the reliability of water supply throughout the system during dry years. Water stored in Sites Reservoir would also enable improvements to the coldwater pools for Trinity Lake, Shasta Lake, Lake Oroville, and Folsom Lake. Water released to the Sacramento River through the Delevan Pipeline would provide water quality benefits in the Delta.

Table ES-4 provides a summary of NODOS Alternatives A, B, and C.

Estimated of Potential Project Accomplishments

Each alternative would result in improvements, to varying degrees, to all of the primary and secondary objectives. Table ES-5 provides a summary of the potential benefits of the alternative plans. Figure ES-8 depicts how the additional water would be used to accomplish the various project purposes.

Integrating the additional water stored with Alternatives A, B, and C would significantly increase the flexibility of CVP and SWP system operations. More water could be stored on average in Trinity Lake, Shasta Lake, Lake Oroville, and Folsom Lake. Figure ES-9 shows the potential/estimated increases in long-term average (October through September) and driest periods average (October through September) storage in CVP and SWP reservoirs for the three alternative plans. The additional storage (800 to 1,400 thousand acre-feet) could significantly increase the flexibility of system operations to respond to system needs.

Figure ES-10 conceptually illustrates how the changes in operations under the NODOS alternatives, to varying degrees, would improve conditions for anadromous fish.

Table ES-4. Description of Alternative Plans

Alternative	A	B	C
Storage Capacity			
Sites Reservoir – Storage Maximum Water Surface Surface Area	1.27 MAF 480 feet msl 12,400 acres	1.81 MAF 520 feet msl 14,000 acres	1.81 MAF 520 feet msl 14,000 acres
Conveyance Capacities (to Sites Reservoir)			
Tehama-Colusa Canal	2,100 cfs	2,100 cfs	2,100 cfs
Glenn-Colusa Canal	1,800 cfs	1,800 cfs	1,800 cfs
Delevan Pipeline ^a Diversion Release	2,000 cfs 1,500 cfs	No Diversion 1,500 cfs	2,000 cfs 1,500 cfs
Delevan Pipeline and Associated Intake or Discharge Facilities	Sacramento River Pumping/ Generating Plant pumping capacity of 2,000 cfs and generating capability of 12 MWs at 1,500 cfs.	Reinforced concrete structure, which would house a flow meter and cone valve and dissipate releases up to 1,500 cfs at the Sacramento River.	Sacramento River Pumping/ Generating Plant pumping capacity of 2,000 cfs and generating capability of 12 MWs at 1,500 cfs.
Hydropower Generation			
Sites Pumping/Generating Plant Generation Capacity	100 MWs	125 MWs	125 MWs
Operations Priorities (Primary Planning Objectives)			
Long-Term (all years)	EESA Power ^b M&I	EESA Power ^b M&I	EESA Power ^b M&I
Driest Periods (drought years)			
Average to Wet Periods (non-drought years)	Water Quality Level 4 Refuge Agricultural	Water Quality Level 4 Refuge Agricultural	Water Quality Level 4 Refuge Agricultural
Anadromous Fish Measures (nonoperational; in addition to ecosystem enhancement-associated operations changes)			
Establish an Environmental Enhancement Fund	✓	✓	✓

^a A pump station, intake, and fish screens are not included for the Delevan Pipeline for Alternative B. The Delevan Pipeline would be operated for releases only from Sites Reservoir to the Sacramento River year round.

^b Includes dedicated pumping/generating facilities with dedicated afterbay/forebay of 6.5 TAF in Holthouse Reservoir (enlarged Funks Reservoir) used for managing conveyance of water between Sites Reservoir and river diversion locations.

cfs = cubic foot per second

EESA = ecosystem enhancement storage account

MAF = million acre-feet

MW = megawatt

M&I = municipal and industrial

msl = mean sea level

TAF = thousand acre-feet

Table ES-5. Summary of Potential Relative Accomplishments of Alternative Plans and Estimates of Preliminary Costs and Benefits

Item/Objective	ALT A	ALT B	ALT C
Reservoir Size (MAF)	1.27	1.81	1.81
New Sacramento River Diversion	Yes	No	Yes
<i>Water Supply and Water Supply Reliability</i>			
Water Supply Increase (TAF/year)	213	213	246
Total Releases from Sites Reservoir (TAF/year)	425	429	488
Increase Water NOD (TAF/year)	37	23	39
Increase Water SOD (TAF/year)	132	118	133
Level 4 Refuge Supply Contribution (TAF/year)	44	72	74
<i>Water Quality</i>			
Water Supply for Water Quality Improvement (TAF/year)	128	136	165
Delta Water Quality – Downstream shift in X2 (July/August) (kilometers)	1.4	1.4	1.7
<i>Anadromous Fish and Other Aquatic Species</i>			
Water Supply for EESA (Average/Dry Year) (TAF/year)	84/91	80/98	77/86
Winter-Run Chinook Egg – Fry Survivability (percent increase from No Project Alternative)	26%	21%	33%
Winter-Run Chinook Fish Production (percent increase from No Project Alternative)	3%	1%	3%
Fall-Run Chinook Fish Production (percent increase from No Project Alternative)	10%	9%	12%
<i>Flexible Hydropower Generation</i>			
Hydropower Generated Annually (in GWh)	184 to 301	143 to 336	169 to 353
<i>Recreation</i>			
Recreation	Low	Medium	Medium
<i>Flood Damage Reduction</i>			
Flood Damage Reduction (acres)	8,625	8,625	8,625
<i>Benefits</i>			
Annual Benefits (\$M)	248	255	276

ALT = alternative

EESA = ecosystem enhancement storage account

GWh = gigawatt-hour

MAF = million acre-feet

NOD = North of Delta

SOD = South of Delta

TAF = thousand acre-feet

\$M = 2013 dollars (millions)

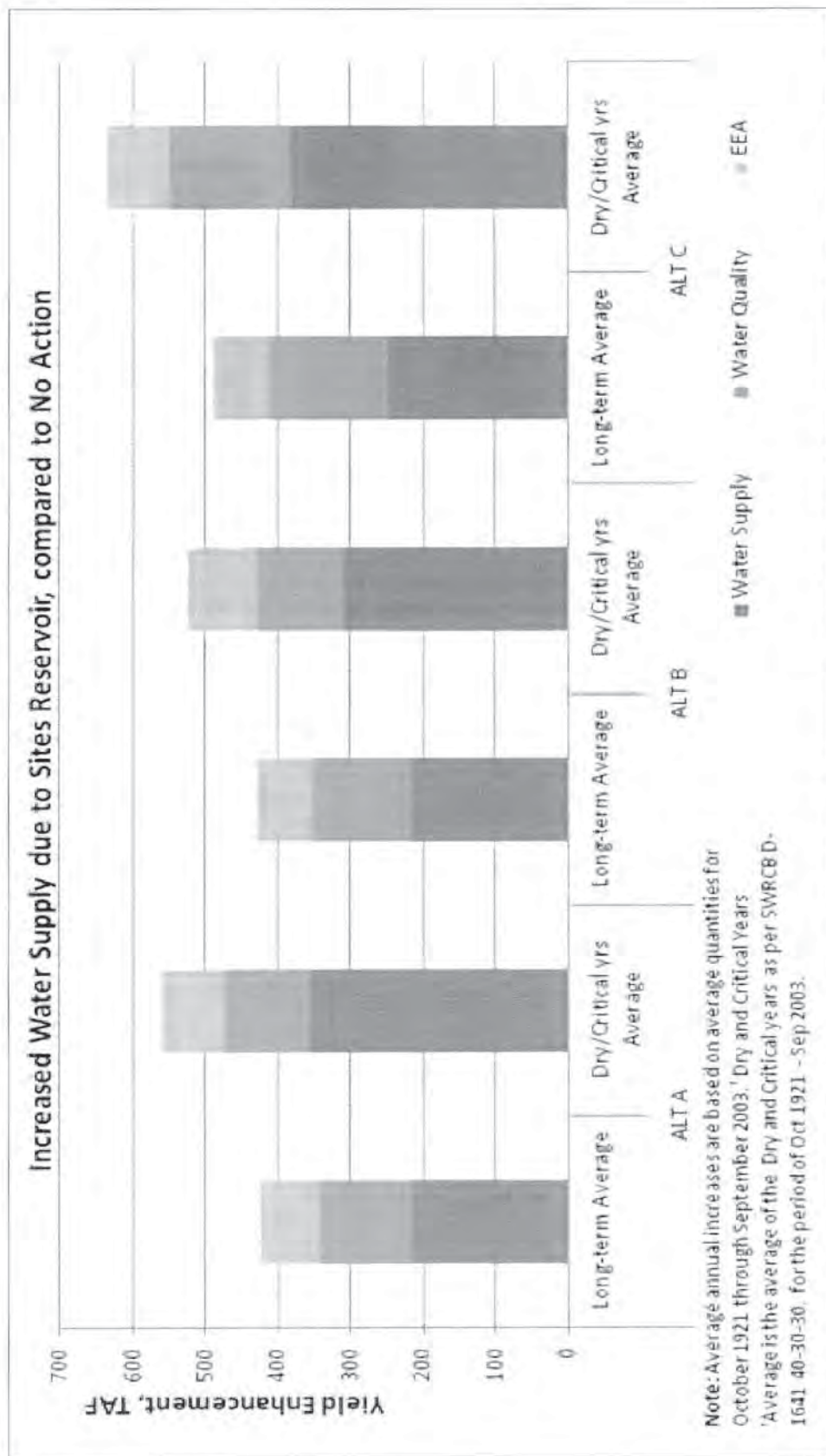
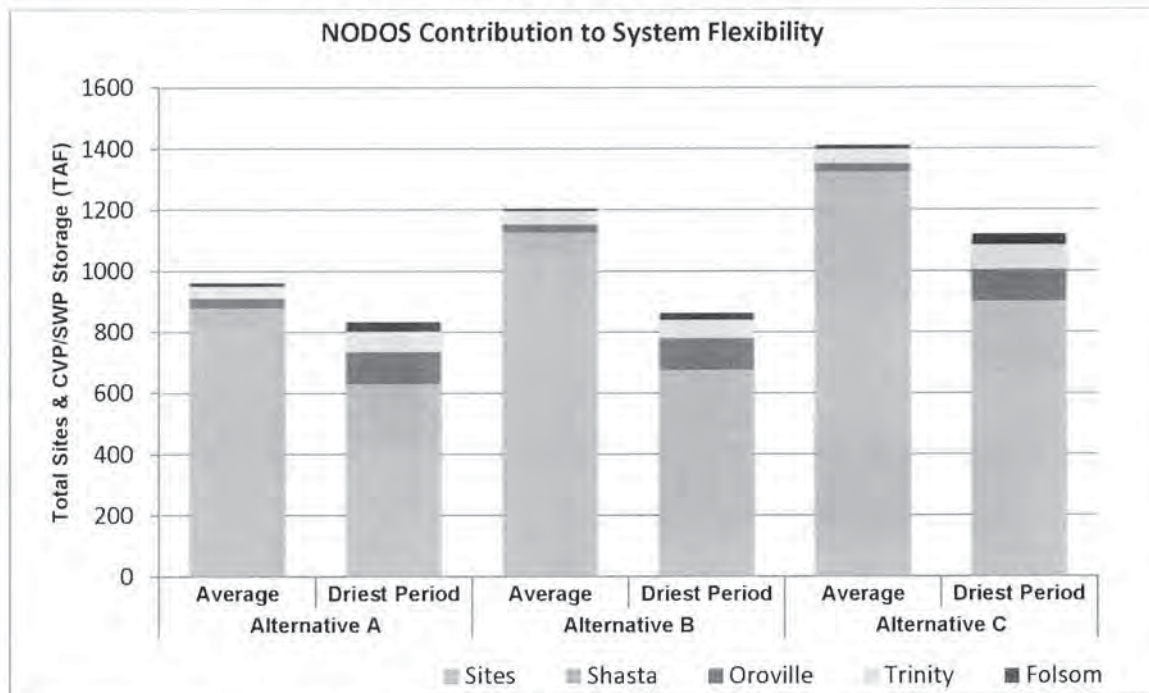


Figure ES-8. Enhancement of Water Supply for Project Purposes Compared to No Project Alternative



Driest periods are essentially the drought years in the 83-year full-simulation sequence (i.e., 1928 to 1934, 1976 to 1977, and 1987 to 1992). These years are designated as multiple year dry sequences, rather than each individual year, as designated by the Indices.

Figure ES-9. Increases in Average System Storage Compared to the No Project Alternative

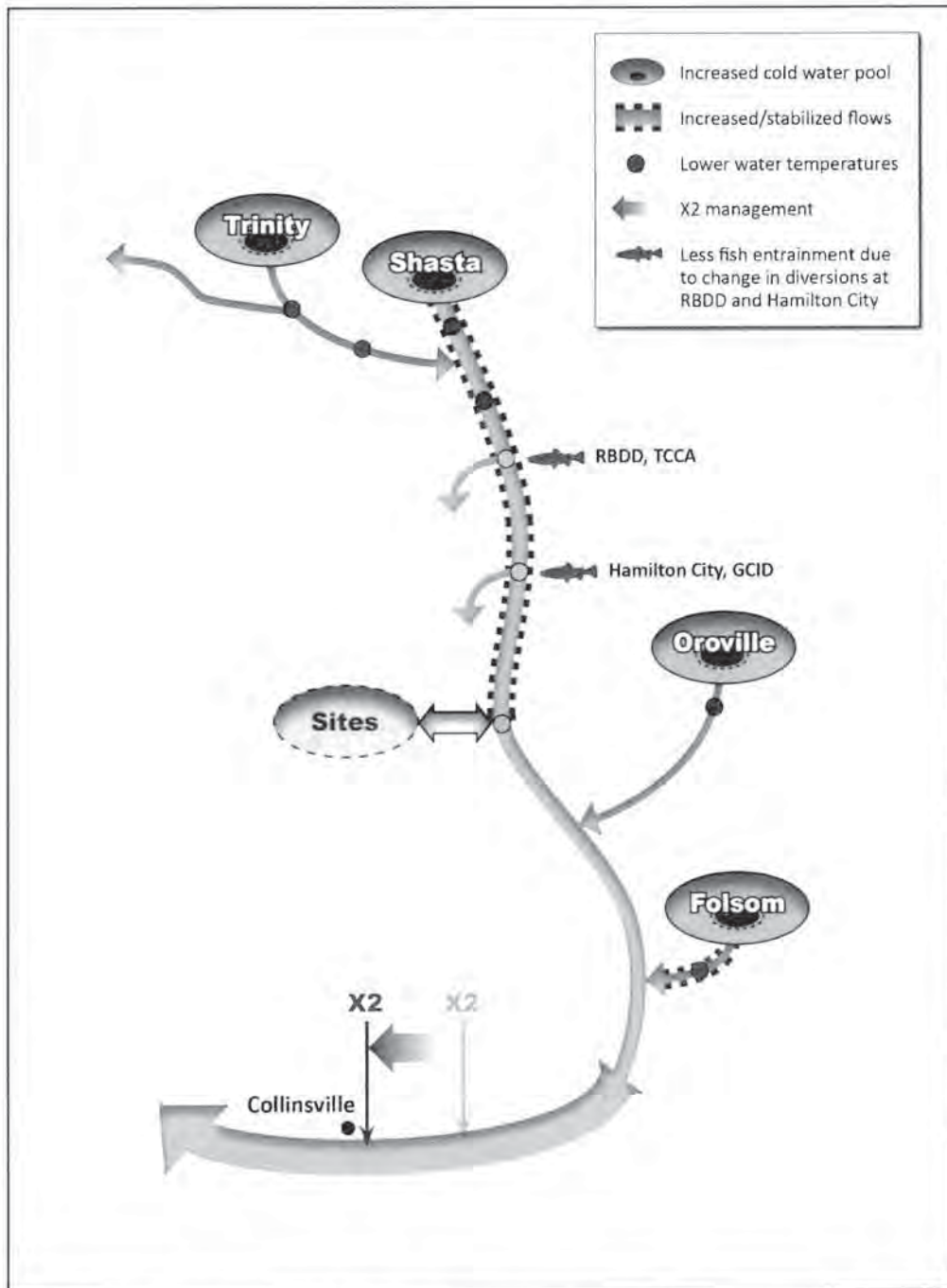


Figure ES-10. Potential Aquatic Enhancement at CVP and SWP Facilities from Implementation of NODOS Alternative Plans

Estimated Benefits

NODOS would provide a variety of benefits in accordance with the primary and secondary objectives. Table ES-6 summarizes the results of the economic benefit analysis.

Table ES-6. Summary of Estimated NED Benefits for NODOS Alternative Plans (\$M, 2013 Dollars)^a

Beneficiary	Alternative A	Alternative B	Alternative C
Water Supply			
Agricultural	\$12.7	\$7.1	\$11.7
Urban	\$157.6	\$161.1	\$167.6
Refuges	\$12.5	\$20.5	\$21.1
Conveyance (CVP/SWP)	(\$22.9)	(\$22.3)	(\$24.8)
Total	\$159.9	\$166.4	\$175.6
Water Quality			
Agricultural	\$1.2	\$1.4	\$1.7
Urban	\$18.1	\$19.8	\$24.0
Total	\$19.3	\$21.3	\$25.7
Ecosystem Enhancement	\$46.7	\$50.1	\$49.3
Hydropower (system)	\$20.6^b	\$15.1^b	\$23.5
Recreation	\$2.3	\$2.3	\$2.4
Flood Damage Reduction	\$0.0	\$0.0	\$0.0
Total	\$248.8	\$255.2	\$276.2

^a Discounted at the federal discount rate of 3.75% over 100 years.

^b Approximated benefits based on analysis of Alternative C by Toolson and Zhang (2013)

CVP = Central Valley Project
NED = national economic development
NODOS = North-of-the-Delta Offstream Storage
SWP = State Water Project
\$M = 2013 dollars (millions)

Estimated Costs

A feasibility-level design and estimate of probable construction cost is under development for the NODOS alternatives. The Draft Feasibility Report will include an engineering appendix and the estimate of probable construction cost.



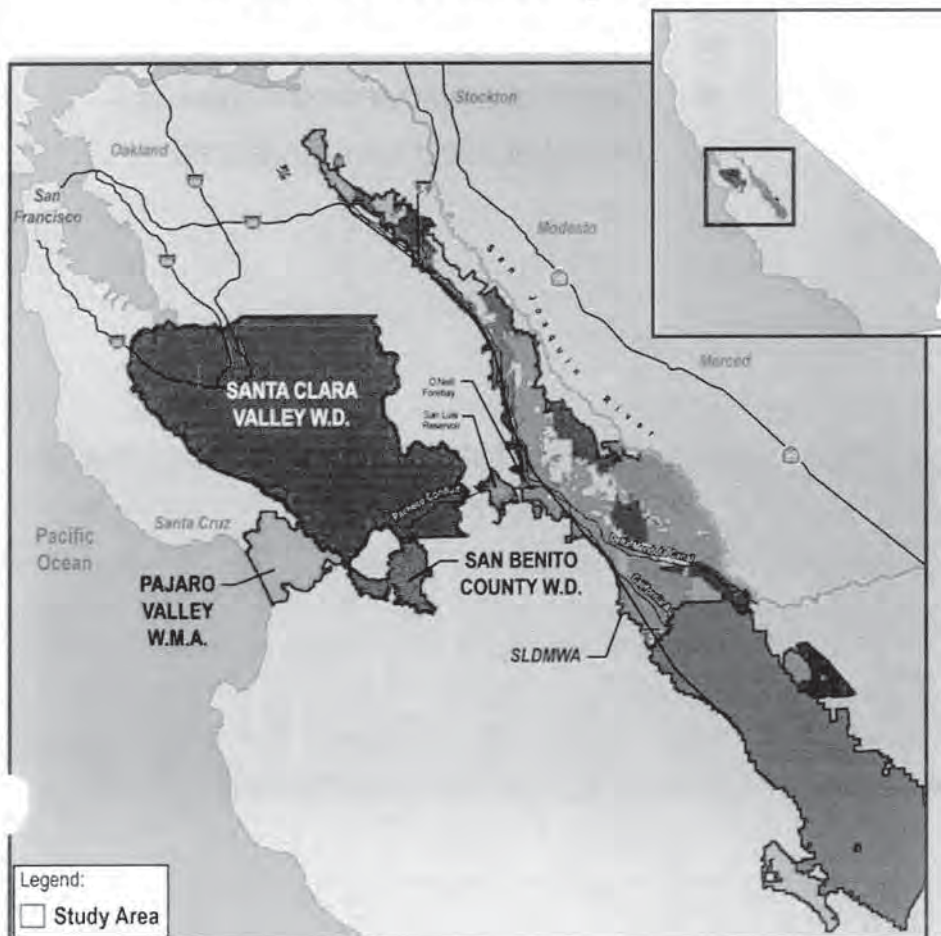
Project Orientation – San Luis Reservoir



With a storage capacity of over 2 million acre-feet, San Luis Reservoir is one of California's largest off-stream reservoirs and is a key element of the State's water supply system.

Water from the Sacramento-San Joaquin Delta is delivered to San Luis Reservoir via the California Aqueduct and Delta-Mendota Canal for storage. In the summer months, water is released from San Luis Reservoir for use by the Federal and State water projects.

EIS/EIR Study Area



The Study Area for the San Luis Low Point Improvement Project consists of:

- San Luis Reservoir;
- The San Felipe Division of the Central Valley Project (CVP), which includes Santa Clara Valley Water District, San Benito County Water District, and Pajaro Valley Water Management Agency; and
- The CVP service areas of the San Luis and Delta-Mendota Water Authority (SLDMWA).



Environmental Review Purpose

Compliance activities associated with the National Environmental Policy Act (NEPA) and the California Environmental Quality Act (CEQA) will:

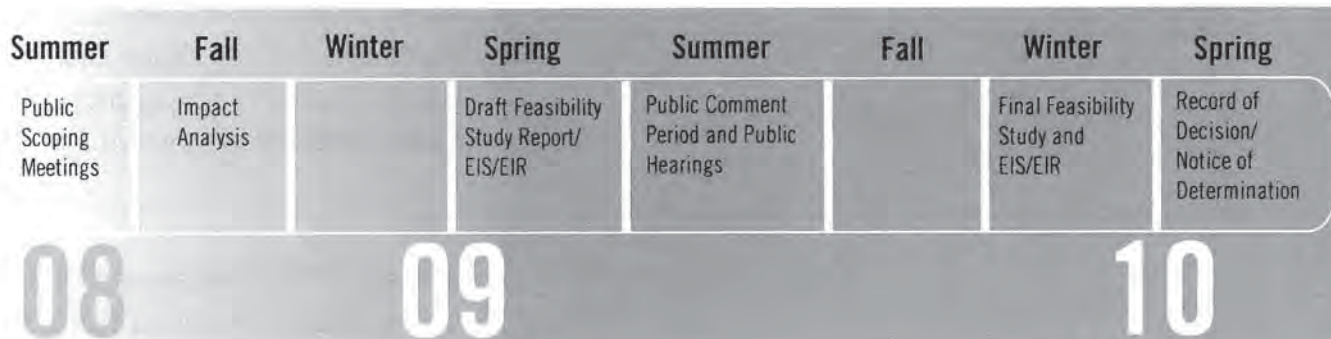
- Evaluate reasonable alternatives that could reduce or avoid environmental impacts
- Provide information for public review and comment
- Identify significant environmental impacts
- Develop mitigation (ways to reduce or avoid environmental impacts)
- Communicate to decision makers the impacts, mitigation, and public comments

What is Scoping?

Public scoping serves to include agencies, stakeholders, and the interested public in the decision-making process and to allow full environmental disclosure. The Bureau of Reclamation (NEPA lead) and the Santa Clara Valley Water District (CEQA lead) invite stakeholder and public input on environmental considerations as part of the scoping process of the Draft EIS/EIR.

Scoping helps to identify and refine:

- Potential options and alternatives
- Potential environmental impacts
- Potential mitigation measures





Project Objectives BDCP1563.

Optimize the water supply benefits of San Luis Reservoir while reducing additional risks to water users by:

- Avoiding supply interruptions when water is needed by increasing the certainty of meeting the requested delivery schedule throughout the year to south-of-Delta contractors dependent on San Luis Reservoir.
- Increasing the reliability and quantity of yearly allocations to south-of-Delta contractors dependent on San Luis Reservoir.
- Announcing higher allocations earlier in the season to south-of-Delta contractors dependent on San Luis Reservoir without sacrificing accuracy of the allocation forecasts.

The San Luis Low Point Improvement Project may provide opportunities for ecosystem restoration.





Santa Clara Valley
Water District



Environmental Issues/ Resources Addressed

BDCP1563.

Hydrology and Water Quality

- Water deliveries
- Water quality

Biological Resources

- Impacts to Federal and State listed species and habitat
- Habitat Conversion
- Impacts to Wetlands

Construction Impacts

- Dust and Air Quality
- Noise

Land Use and

Socioeconomics

- Agricultural Land Conversion
- Recreation
- Cultural Resources

Traffic Impacts

Physical Resources

- Geology, soils, and seismicity
- Visual resources
- Air quality

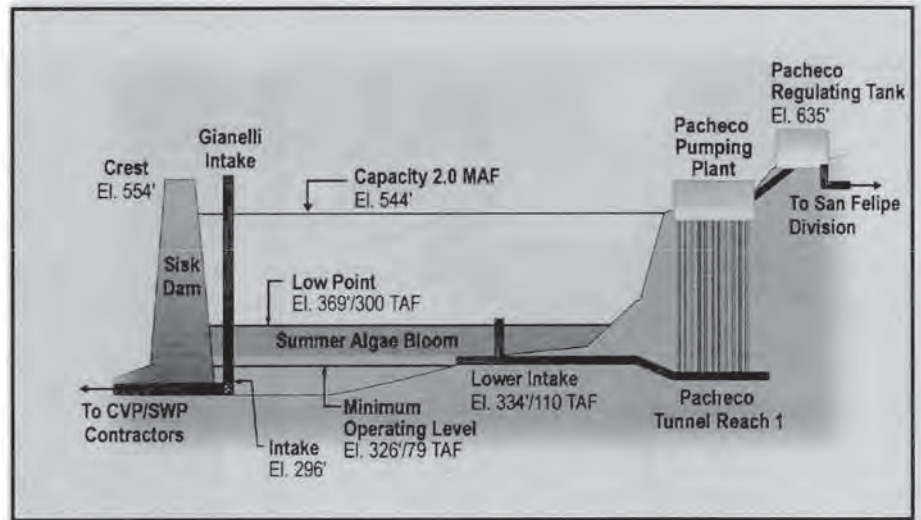
Cumulative Effects





Under regular operations, water is released from San Luis Reservoir to the State Water Project (SWP), the Central Valley Project (CVP), and the San Felipe Division (SFD) of the CVP.

- As the San Luis Reservoir is drawn down during the summer and into the late fall (when water supplies are needed most), a thick layer of algae (as much as 35 feet thick) grows on the surface.
- As the water level lowers, this algae gets captured by SFD intakes.
- The algae degrades water quality and makes water more difficult to treat.
- As a result, **San Felipe Division deliveries can be interrupted when the reservoir falls below 300,000 acre-feet.**
- These delivery interruptions are critical because the San Luis Reservoir is the only CVP water source that SFD contractors can access.



Potential effects of these issues include:

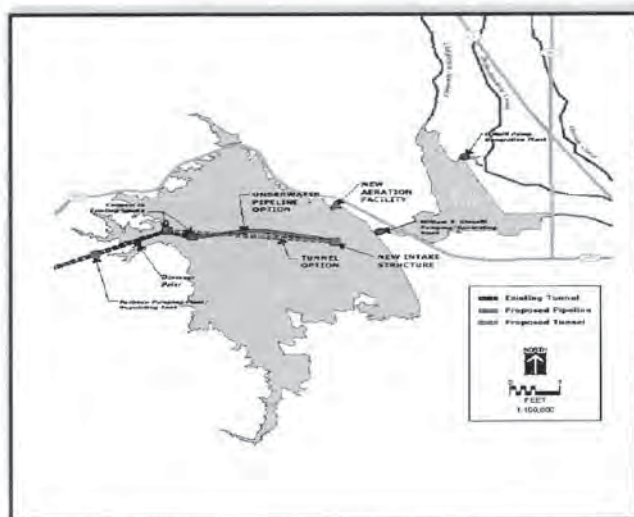
- Interruption of water deliveries to domestic, industrial, and agricultural users
- Interruption of water deliveries used to replenish groundwater supplies
- Blockage of agricultural irrigation systems
- Reduced ability to treat water effectively
- Increased water treatment costs
- Taste and odor problems



A range of 88 management measures were identified through initial studies and public input. These measures were combined into 17 alternatives and further screened for their feasibility and their ability to meet project objectives. This list represents the four alternatives that are the result of a multi-level screening process and will be fully analyzed in the environmental review process.

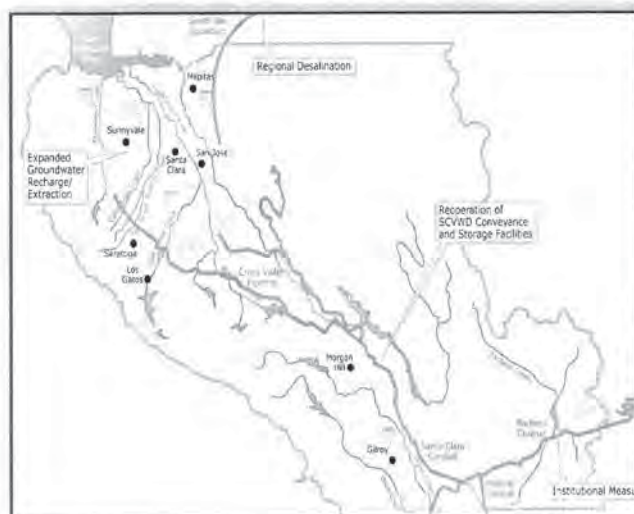
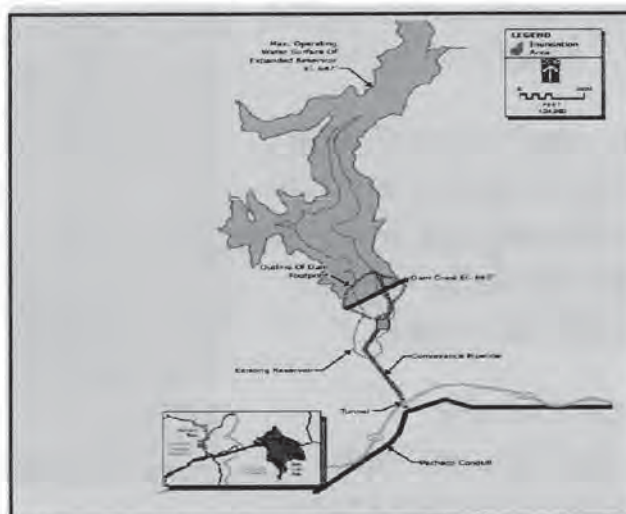
Lower San Felipe Intake

- A new intake would be constructed and connected to the existing San Felipe Division Intake to allow operation of San Luis Reservoir below the 300,000 acre-foot level without creating the potential for a water supply interruption to the San Felipe Division.



Pacheco Reservoir Expansion

- A new dam and reservoir would be constructed on Pacheco Creek to store San Felipe Division supplies for delivery during low point months. The new dam and reservoir would inundate the existing 6,000 acre-foot Pacheco Reservoir, owned and operated by the Pacheco Pass Water District. Two alternative sizes are being considered; an 80,000 acre-foot reservoir and a 130,000 acre-foot reservoir. The new reservoir would permit full exercise of San Luis Reservoir while avoiding supply interruptions.



Combination Comprehensive Plan

- Includes multiple structural components and management measures to maximize operational flexibility and supply reliability in the San Felipe Division, including increased groundwater aquifer recharge and recovery capacity, desalination, re-operation of Santa Clara Valley Water District raw and treated water systems, and institutional measures. The Combination Comprehensive Plan relies on these new local supplies and stored reserves in the San Felipe Division during low point supply interruptions to meet demands and allow full exercise of San Luis Reservoir.

No Project/ No Action

- Examines the impacts of taking no action (or not implementing the project).

Suisun Marsh Habitat Management, Preservation, and Restoration Plan

Draft Environmental Impact Statement/ Environmental Impact Report

Executive Summary

SCH#: 2003112039



U.S. Department of the Interior
Bureau of Reclamation



U.S. Fish and Wildlife Service



California Department of Fish
and Game

October 2010

Appendix A
**Numerical Modeling
in Support of Suisun Marsh PEIR/EIS—
Technical Appendix, September 2009**

1. Executive Summary

1.1. Background

Resource Management Associates, Inc. (RMA) has developed a numerical model of the Suisun Marsh area to simulate the current hydrodynamics and salinity of the marsh as well as the changes to this regime under a set of four marsh restoration scenarios. RMA refined the representation of the Suisun Marsh area in their current numerical model of the San Francisco Bay and Sacramento-San Joaquin Delta system (Bay-Delta model). The computer programs used in the Bay-Delta model, RMA2 (King 1990) and RMA11 (King 1998), utilize a finite element formulation to simulate the one- and two-dimensional flow and water quality transport¹, respectively, in streams and estuaries. The Bay-Delta model, which uses electrical conductivity² (EC) as a surrogate for salinity, has been successively updated, refined and recalibrated in numerous studies over the past 11 years, for example, to evaluate the water quality responses of treated wastewater discharges, and the potential effects of various Suisun Marsh levee breach scenarios.

1.2. Report Summary

This Technical Summary of the Suisun Marsh Modeling Project describes:

- the refined Bay-Delta model;
- the calibration of this representation;
- the further development of the model to represent four representative marsh restoration scenarios; and
- analysis of the modeling results of these scenarios to evaluate their effects on tidal range, scour velocities, and tidal prism in Suisun Marsh, and on salinity in Suisun Marsh and the Delta in comparison with simulated Base case conditions.

1.3. Summary of the Calibration

RMA's Bay-Delta model was refined in the Suisun Marsh area, with increased detail to represent off-channel storage in overbank/fringe marsh regions, a better representation of precipitation and evaporation, estimation of local creek flows, inflows and withdrawals within the Suisun Marsh, plus an overall refinement of the mesh. These additions generally improved the representation of tidal dynamics and EC in Suisun Marsh. A recent Delta calibration effort (RMA, 2005) was used as the starting point for the current effort. There was no recalibration in the Delta, as the focus was on improving the representation of Suisun Marsh.

Hydrodynamic calibration of the refined model took place in the period April – July, 2004 to take advantage of new LiDAR elevation data and data from new flow and stage measurement stations in the Suisun Marsh area (DWR 2007). Stage calibration was generally good in Suisun Marsh. The results of the flow calibration were mixed. Flows in

¹ RMA11 can also be used to simulate three-dimensional transport in conjunction with other RMA model formulations, for both conservative and non-conservative constituents.

² EC measurements give an estimate of the amount of total dissolved solids in the water; units are typically given in $\mu\text{mhos cm}^{-1}$ or, equivalently, $\mu\text{S cm}^{-1}$

the smaller sloughs were greatly improved by the increased detail and refinement of the grid, the addition of off-channel storage, withdrawals for managed wetlands, and representation of evaporation in the tidal marsh areas. Flow through Montezuma Slough was low in comparison with measured data, and low flows through Hunter Cut were compensated by higher flows through Suisun Slough. These results have the potential of biasing modeled EC in the marsh restoration scenarios.

EC calibration results were also mixed, with some areas showing good correspondence with measured data, while other areas suffered from approximations intrinsic to the model or from the lack of sufficient data. In particular, density stratification is not explicitly represented in the 2-dimensional depth-averaged formulation used in the Bay-Delta model, leading to variations in the representation of EC. In the current model, diffusion coefficients are used to approximate effects due to density stratification. Using this method to improve the representation of EC during high flow periods tends to bias modeled EC when outflow is low. As a consequence, modeled EC at Martinez is low winter through spring and high summer through fall. This bias in modeled EC at Martinez propagates through western Suisun Marsh. In general, EC was low everywhere in the marsh in winter 2003. EC was low year-round in the eastern end of Montezuma Slough.

1.4. Summary of the Modeling Results

Four scenarios (Figure 1-1) for representative tidal marsh restoration in Suisun Marsh were modeled and compared to a Base case. The scenarios present a range of locations and acreages for restoration projects. Locations where levees were breached are indicated on Figure 1-1. As expected, each of the scenarios increased the tidal prism, i.e., the volume of water exchanged in the Suisun Marsh area, but muted the tidal range and shifted stage timing throughout the marsh in comparison with the Base case. Average tidal flow generally increased in the larger sloughs and decreased in smaller sloughs in the interior regions of Suisun Marsh. The peak velocity increased in sloughs near the breaches of the flooded areas, with the largest velocity changes localized at and near the mouths of the breached levees.

Electrical conductivity ($\mu\text{mhos cm}^{-1}$ or $\mu\text{Siemens cm}^{-1}$), or EC, was modeled as a surrogate for salinity. One part per thousand EC is equivalent to about $1.5 \mu\text{mhos cm}^{-1}$ of EC. EC in the Delta was similar to the Base case in each scenario January – June, but changed July – December in several of the scenarios. Delta EC decreased during the latter period for the Zone 4 and Set 1 scenarios where the breached areas were located in channels further from Suisun, Grizzly and Honker Bays. The Set 2 scenario resulted in EC increase in the Delta due to tidal trapping³ in the breached area adjacent to Suisun Bay. Tidal trapping in Zone 1 caused only minor increases in Delta EC.

Tidal restoration scenarios that decreased Delta EC tended to increase EC in Suisun Marsh, although changes in the details of the EC profile for each scenario depended on

³ Tidal trapping refers to the dispersive mechanism by which differences in tidal phase between a main channel and side channel or embayment create a net horizontal dispersion, in this case, of EC.

the particular location examined, the operation of the Suisun Marsh Salinity Control Gate (SMSCG), and the season. The Zone 1 scenario was most similar to the Base case, with little or no EC change in the eastern marsh but some increase in the west. The Zone 4 scenario decreased EC in most of the marsh whenever the SMSCG was operating, except in eastern Montezuma Slough where it increased EC. The Set 1 scenario generally resulted in the highest EC conditions in the Marsh, except upstream of the Zone 4 breaches on Montezuma Slough. The Set 2 scenario tended to increase EC in much of the marsh when the SMSCG was operating, with variable increase or decrease otherwise.

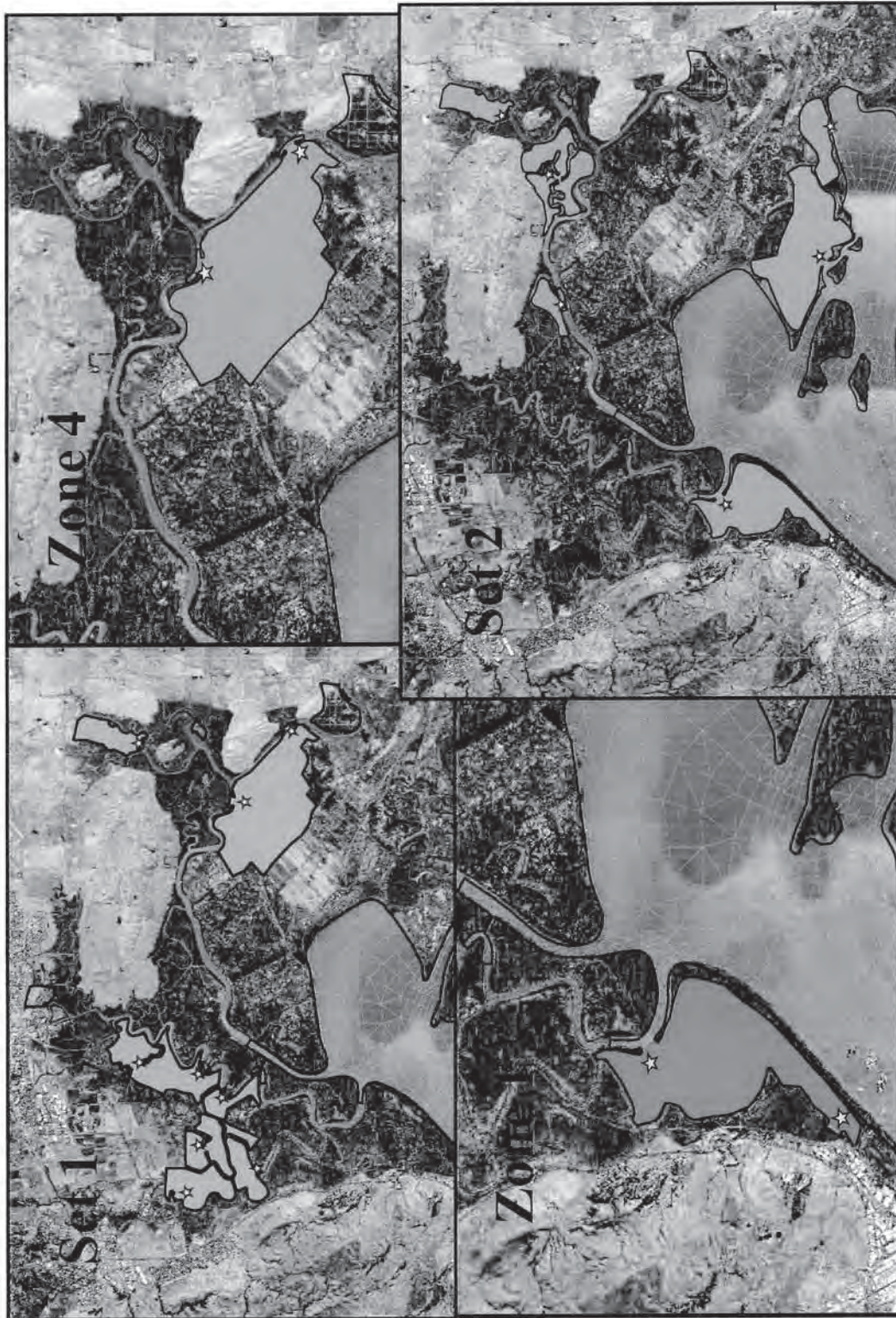


Figure 1-1 Regions flooded as tidal marsh in each of the scenarios, with the location of breaches in levees indicated by stars.

5.6. EC Results

To present a clear picture of the effects of the scenarios on EC in Suisun Marsh and in the Delta, several types of plots are provided. These include time series plots of the scenario EC at selected locations in Suisun Marsh and the Delta; color contour plots of percent change from base; comparison plots of Base case and scenario EC in Suisun Marsh; and comparison plots of Base case and scenario EC in the Delta. For all of the scenarios, large percent changes calculated in the winter are due to very low values, i.e. relatively small increases in modeled EC can translate to large percent increases. Therefore, contour plots of % change during the winter are not provided.

5.6.1. Martinez to Collinsville

Tidally averaged EC at Martinez (Figure 5-19) is relatively uniform between scenarios. However, upstream at Chipps and Collinsville, Figure 5-20 and Figure 5-21 respectively, the effect of the Set 2 tidal restoration with breaches between Honker and Grizzly Bays is seen as a pronounced increase in EC throughout the year.

5.6.2. Suisun Marsh

Changes in the details of the EC profile for each scenario depended on the particular location examined, the operation of the SMSCG, and the season. Each of the scenarios resulted in EC increases in Montezuma Slough at Beldon's Landing. Tidally averaged EC for the Base case and the four restoration scenarios are plotted in Figure 5-22 through Figure 5-34 for locations throughout Suisun Marsh.

The Set 1 scenario produced the greatest increases in EC throughout much of Suisun Marsh, as most of the tidal marsh restoration occurs in the interior portions of the marsh and off of Montezuma Slough. See for example, stations S-49 at Beldon's Landing, S-40 at Boynton Slough, and S-97 at Ibis in Figure 5-22 through Figure 5-24. At Beldon's Landing, the Zone 4 breaches pull high salinity water in from western Montezuma Slough increasing EC there year-round. The Set 1 breaches in north-western Suisun Marsh increase EC near those locations, again through the increased volume of higher salinity moving up western Montezuma Slough.

Effects from Set 1 restoration in the western portions of the marsh primarily result from the breaches in that area, as can be seen when comparing results with the Zone 4 scenario results at station S-97, Figure 5-24. Zone 4 had very little effect on EC in the western and northern marsh when the SMSCG was open and decreased EC when SMSCG was operating, as illustrated in Figure 5-24 through Figure 5-31.

Zone 4 increased EC at Beldon's landing regardless of the SMSCG status. In eastern Montezuma Slough at National Steel (Figure 5-33) and Roaring River (Figure 5-34), EC decreased when SMSCG was open and increased when the gates were operating.

In eastern Montezuma Slough, Set 1 reduced EC when the SMSCG was open (see station S-64 at National Steel, Figure 5-33 and station S-71 at Roaring River, Figure 5-34). The

Zone 4 breaches on Montezuma Slough pull high EC water into the marsh from the west during flood tide. Ebb flows on the upstream side of the breaches pull additional lower EC Sacramento River water into the eastern end of Montezuma Slough. This is illustrated in Figure 5-40, which shows color contours of EC for the Base case and Zone 4 scenario at the same timing on a flood tide and on an ebb tide.

The Zone 1 restoration increased EC throughout much of the marsh. As shown in the color contour plot of percent change in EC in Figure 5-47, % EC in Grizzly Bay at the mouth of Montezuma Slough is about 4.5% higher than the Base case with similar increases at the mouth of Suisun Slough. The flows that progress up Suisun Slough past the Zone 1 breach are smaller than in the Base case due to the breach, and the marsh is being filled with higher EC water from the mouth of Montezuma Slough in the west.

The Zone 1 scenario EC results were the most similar to the Base case, showing little difference from the Base case in the eastern Marsh (station S-64 at National Steel and station S-71 at Roaring River) and at Morrow Island (station S-35, Figure 5-26), but resulted in at least some EC increase in the western Marsh (for example, S-42 in Volanti Slough, Figure 5-27 and S-21 on Sunrise Slough, Figure 5-25) and in Montezuma Slough near Beldon's Landing.

The Set 2 scenario, which incorporates Zone 1, increased EC when the SMSCG was operating. In the western and central marsh (for example S-21 and S-49), EC was increased throughout the simulation, but at Morrow Island, Set 2 resulted in little change when the SMSCG was not operating. When the SMSCG was not operating, EC decreased appreciably only in eastern Montezuma Slough at S-64 and S-71.

Operation of the SMSCG acts to decrease EC in comparison to the Base case. Specific locations on Montezuma Slough illustrate the effect of SMSCG operation and changes in tidal flow due to the breaches.

- S-49 – Beldon's Landing (Figure 5-22): For the Set 2 scenario, the breaches north of Montezuma Slough only affect EC at Beldon's Landing when the SMSCG is operating. This can be seen because Set 2 and Zone 1 EC are nearly the same at this location when the gates are open.
- S-64 – National Steel (Figure 5-33): In general, all of the scenarios decrease EC at S-64 when the SMSCG is open because they decrease the flood tide flow of higher EC water to this location. When the gate is operating, EC increases for Set 2 because EC at the eastern end of Montezuma Slough near Collinsville is higher due to the breaches in Suisun Bay. On ebb tide, this higher EC water flows past S-64. For the Zone 1 scenario, the same thing occurs only the effect is much smaller. For the Set 1 and Zone 4 scenarios, the increase in EC is the result of a change in phasing. The breaches off of Montezuma Slough changed the tidal phasing and amplitude so that flow from Collinsville into Montezuma Slough occurs at high tide, when EC at Collinsville is highest.

5.6.3. Delta

Scenarios that tended to increase EC in Suisun Marsh tended to decreased Delta EC. Delta EC was similar to the Base case in all of the scenarios during early winter through spring, but changed in relation to the Base case during summer through fall. This can be seen in plots of tidally averaged EC for the Base case and four marsh restoration scenarios at several Delta stations in Figure 5-35 through Figure 5-39, and in contour plots of % change from base in Figure 5-41 to Figure 5-53.

The two scenarios incorporating Zone 4 (Zone 4 and Set 1) resulted in a decrease in Delta EC, while the two scenarios incorporating Zone 1 (Zone 1 and Set 2) resulted in an increase in summer through fall Delta EC. This is seen at locations from Jersey Point, Figure 5-35, to various locations in the central and south Delta - at Old River near Rock Slough (5-36), in Victoria Canal (5-37) and at the CVP (Figure 5-38) and SWP (Figure 5-39) export locations.

The Set 2 scenario causes the greatest increase in Delta EC, as shown in Figure 5-41 through Figure 5-46 for the months with the highest EC changes. An example is seen in the color contour plot of percent change from Base case EC for the Set 2 scenario on September 1, 2002 in Figure 5-42. At this time, EC at the SWP is 12% greater than Base and at the CVP, it is 10% greater than Base. These changes are due to tidal mixing in the breaches off of Suisun Bay, which causes increased EC there, and later in the year increased EC up the San Joaquin River into Franks Tract and the western Delta. A similar plot for the Zone 1 scenario, in Figure 5-47, shows that it has minimal change to Delta EC, as the largest increases at the export locations are approximately 2% during the at this time.

The Set 1 and Zone 4 scenarios generally reduce EC at the export locations and in the western Delta summer through fall, as shown in Figure 5-48 through Figure 5-53. The Set 1 scenario produces the largest reductions – approximately 10% near the export locations on September 1, 2002, as shown in the color contour plot in Figure 5-49, while the Zone 4 restoration area alone reduces EC by 5 – 6% near the exports (not shown).

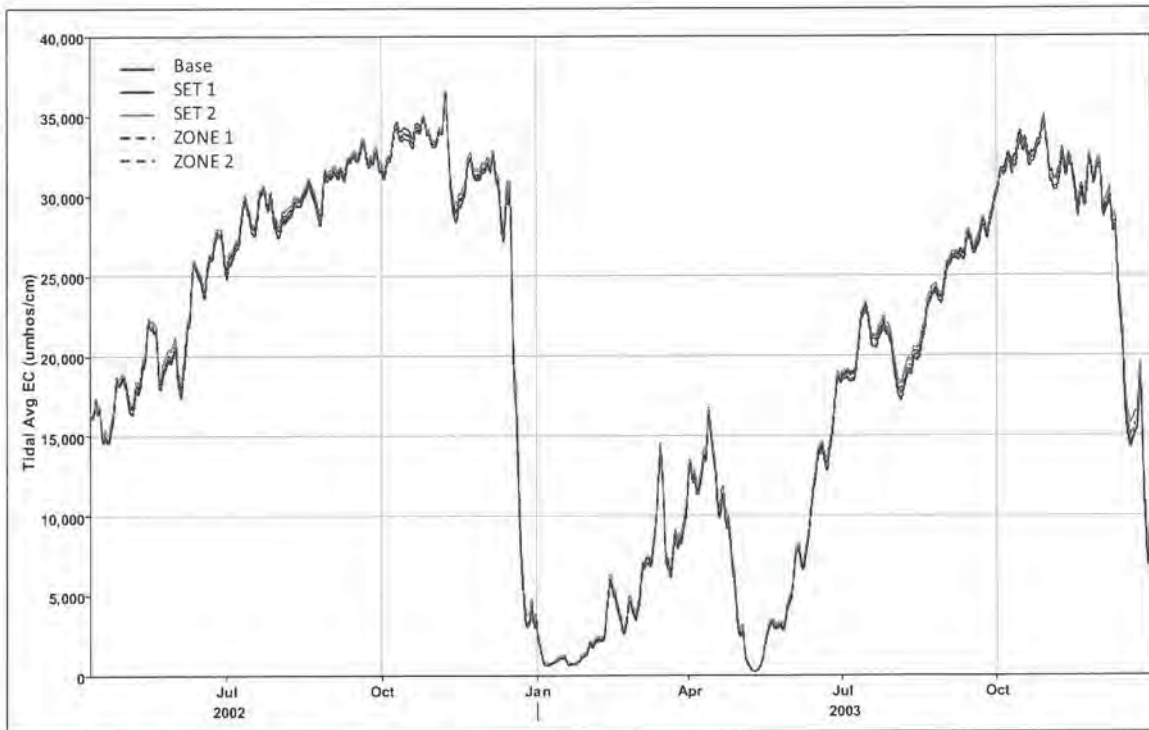


Figure 5-19 Tidally averaged computed EC at Martinez.

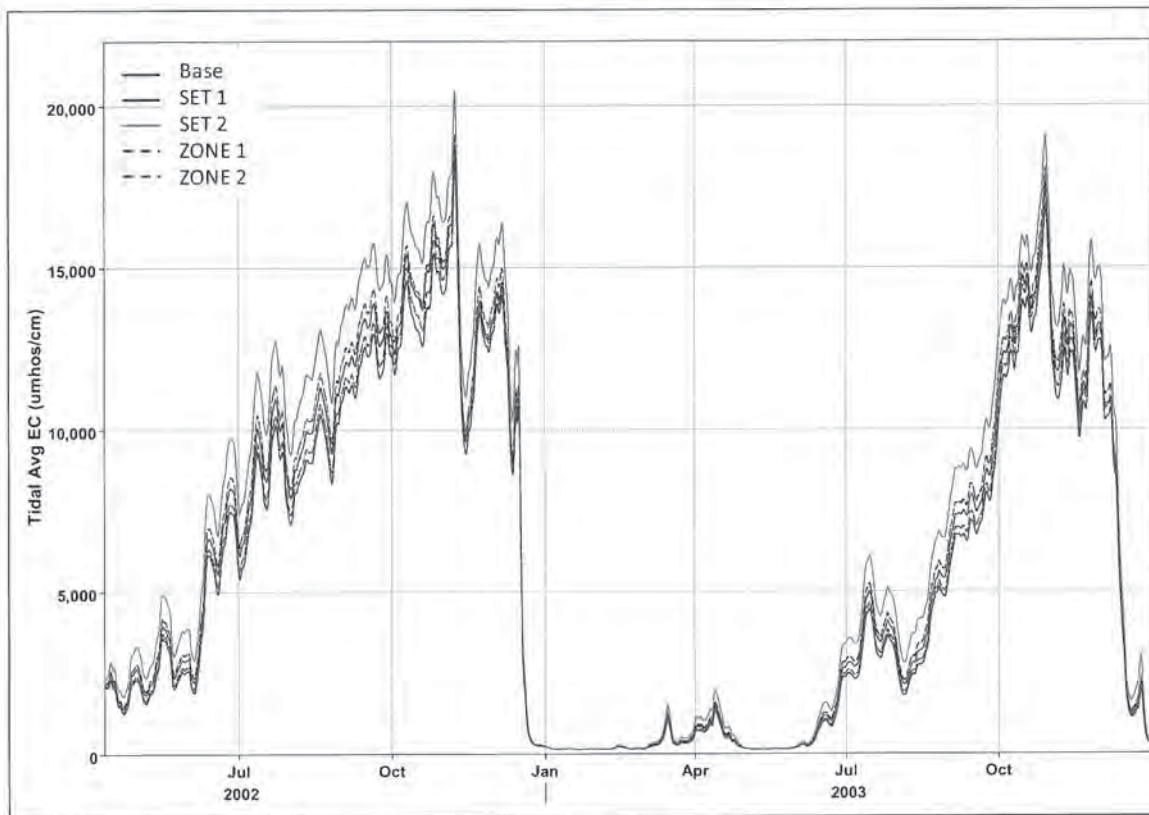


Figure 5-20 Tidally averaged computed EC at Chipps.

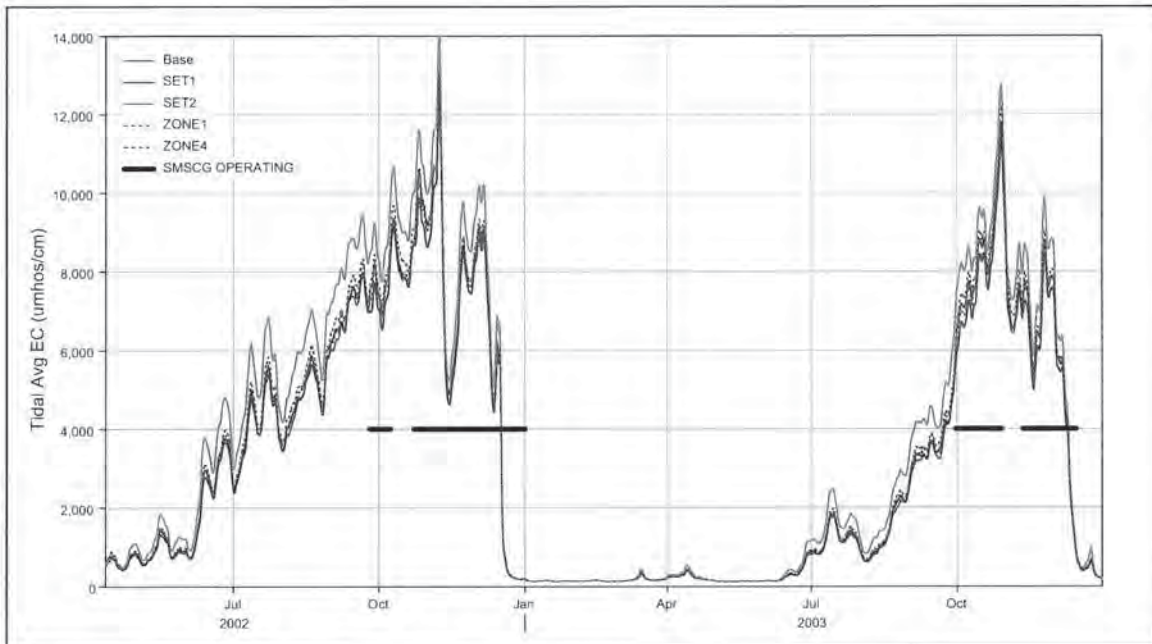


Figure 5-21 Tidally averaged observed and computed EC at Collinsville.

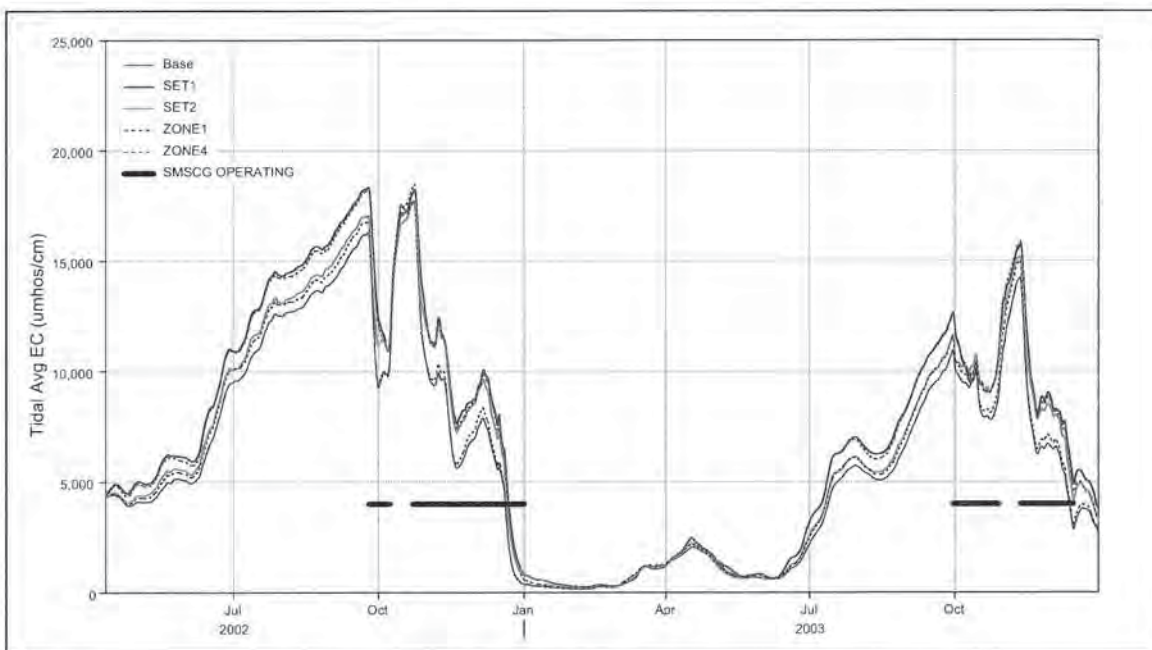


Figure 5-22 Tidally averaged computed EC at Beldon's Landing at monitoring station S-49 in Montezuma Slough.

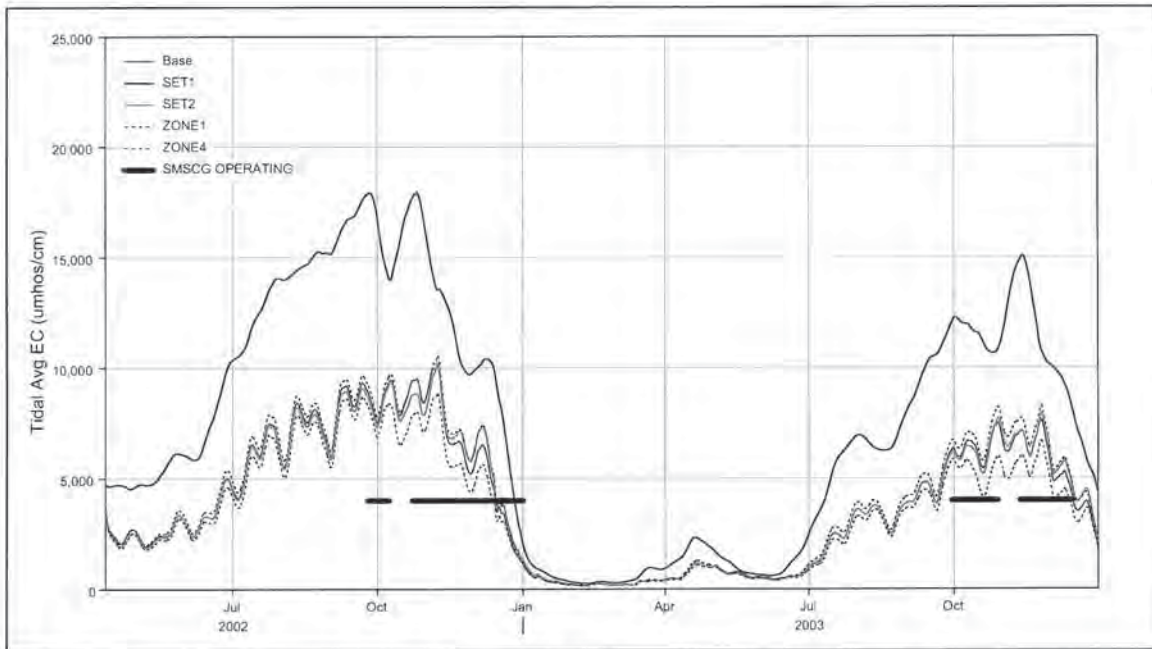


Figure 5-23 Tidally averaged computed EC at station S-40 on Boynton Slough.

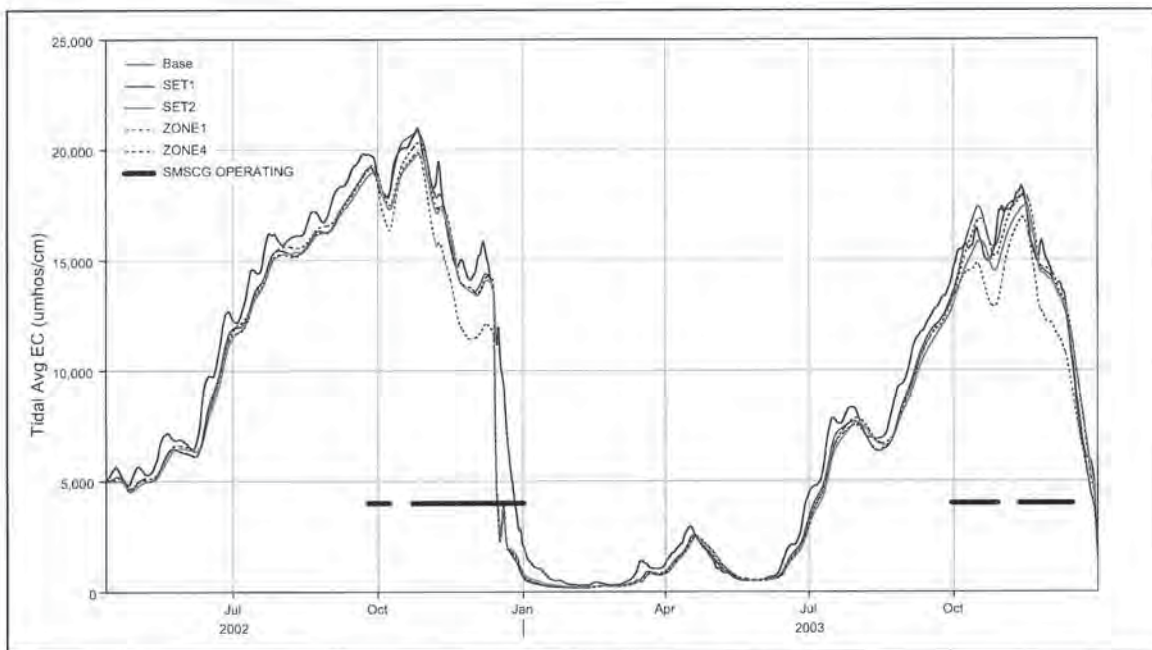


Figure 5-24 Tidally averaged computed EC at station S-97 on Ibis Slough.

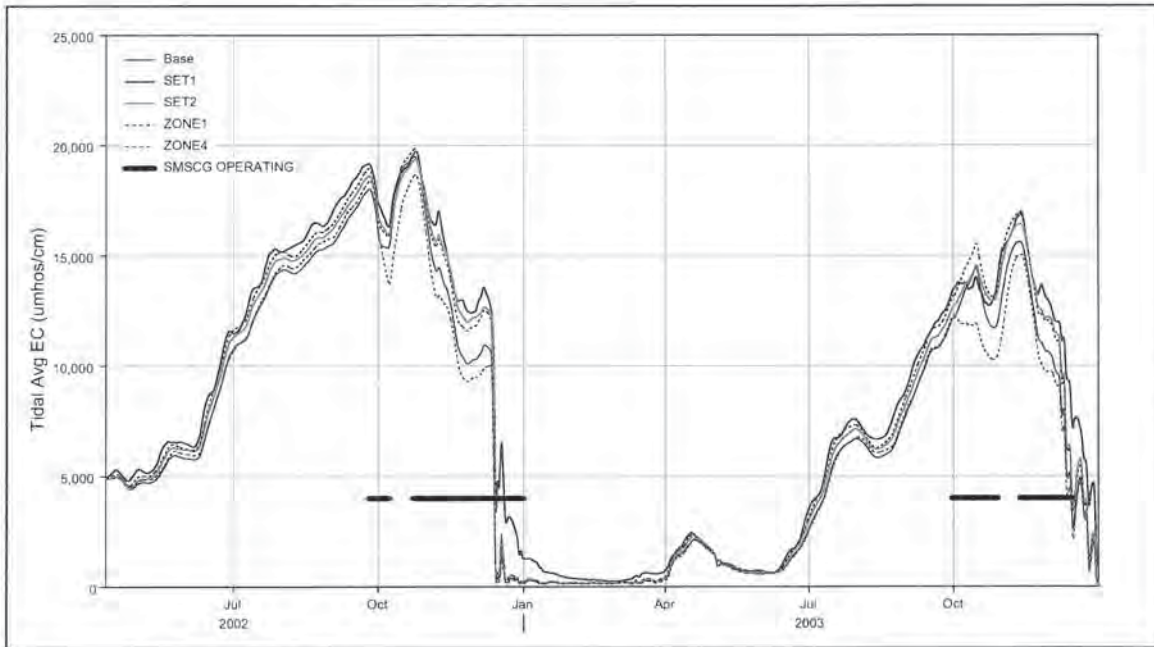


Figure 5-25 Tidally averaged computed EC at station S-21 in Sunrise Slough.

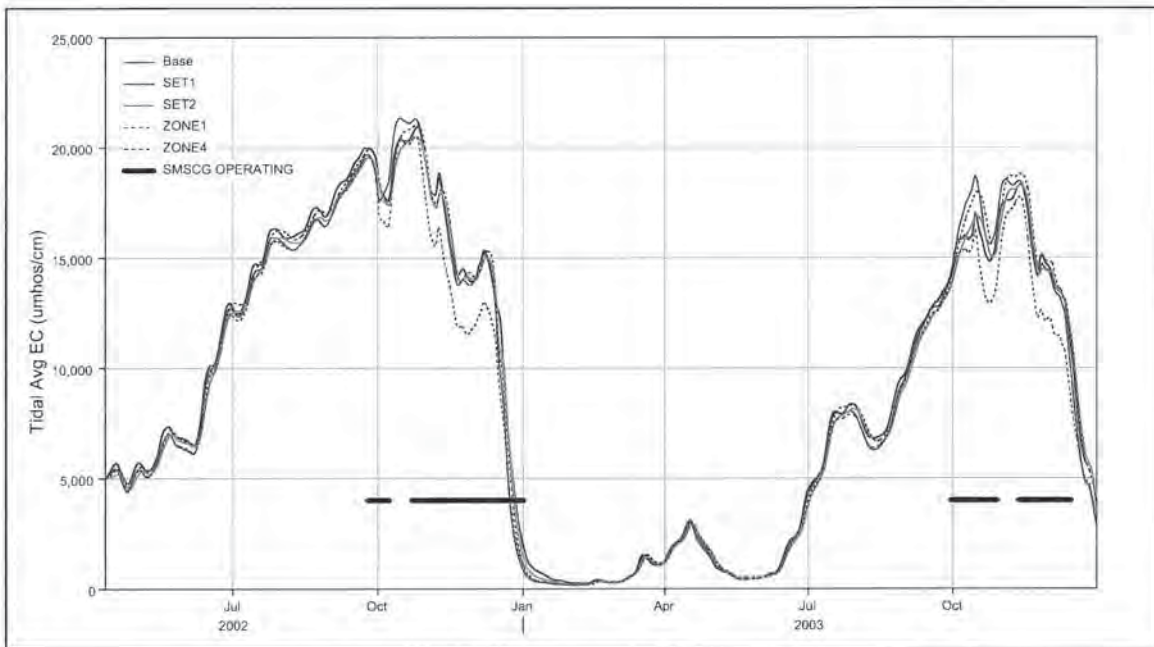


Figure 5-26 Tidally averaged computed EC at station S-35 at Morrow Island.

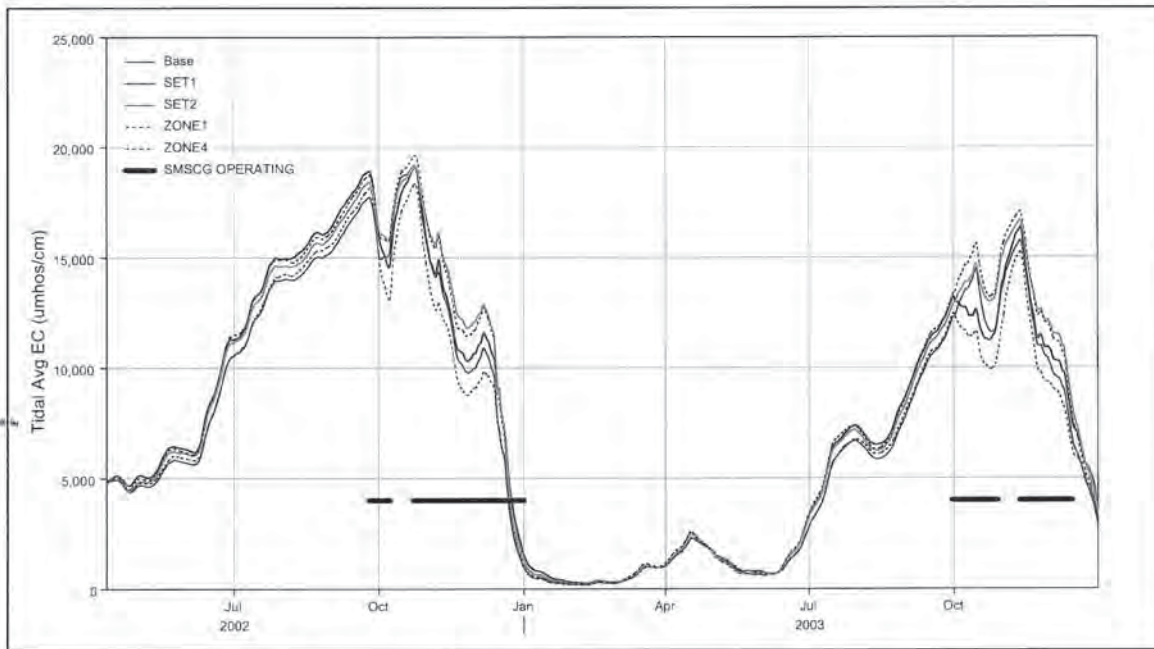


Figure 5-27 Tidally averaged computed EC at station S-42 on Volanti Slough.

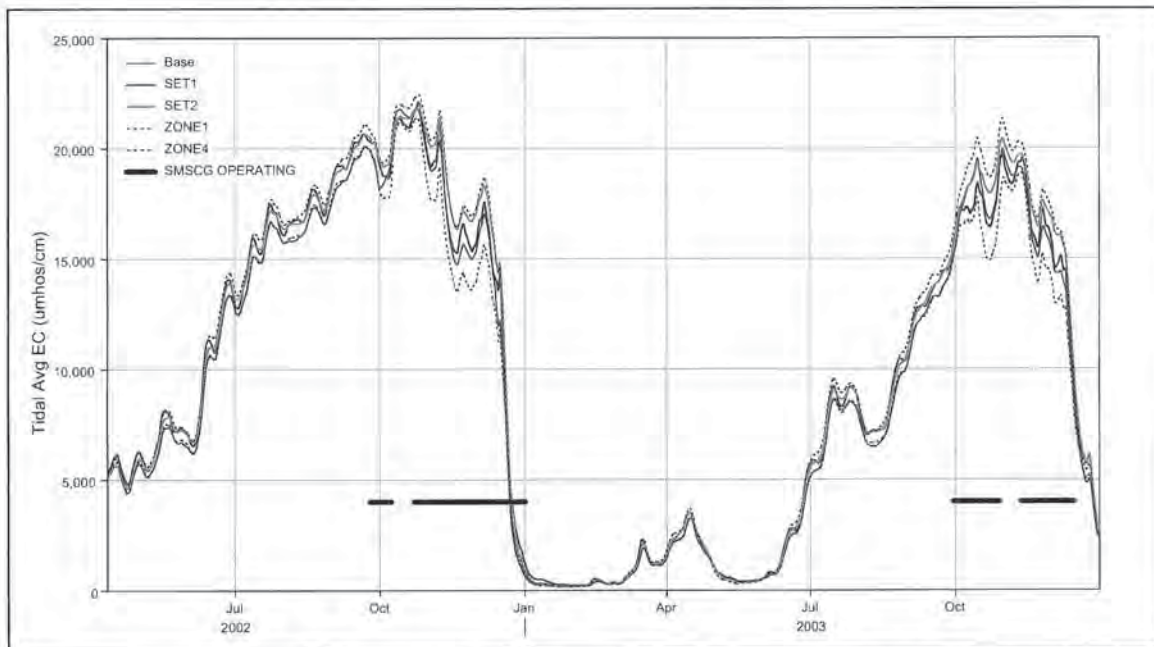


Figure 5-28 Tidally averaged observed and computed EC at station S-37 on Godfather Slough.

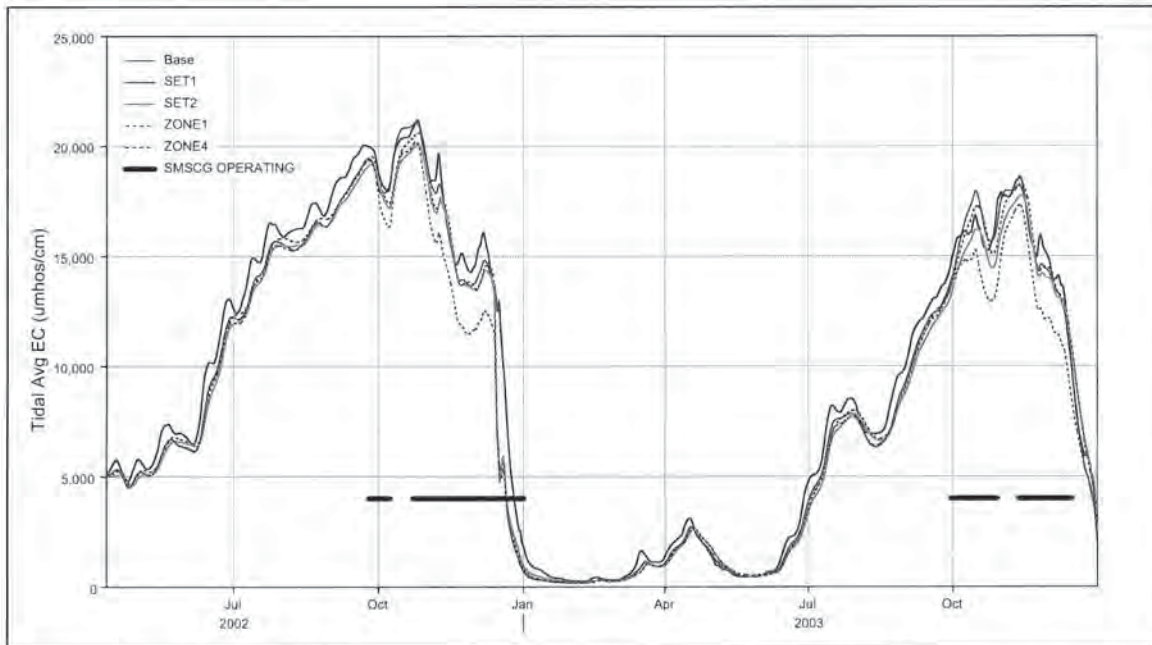


Figure 5-29 Tidally averaged observed and computed EC at station S-33 on Cygnus Slough.

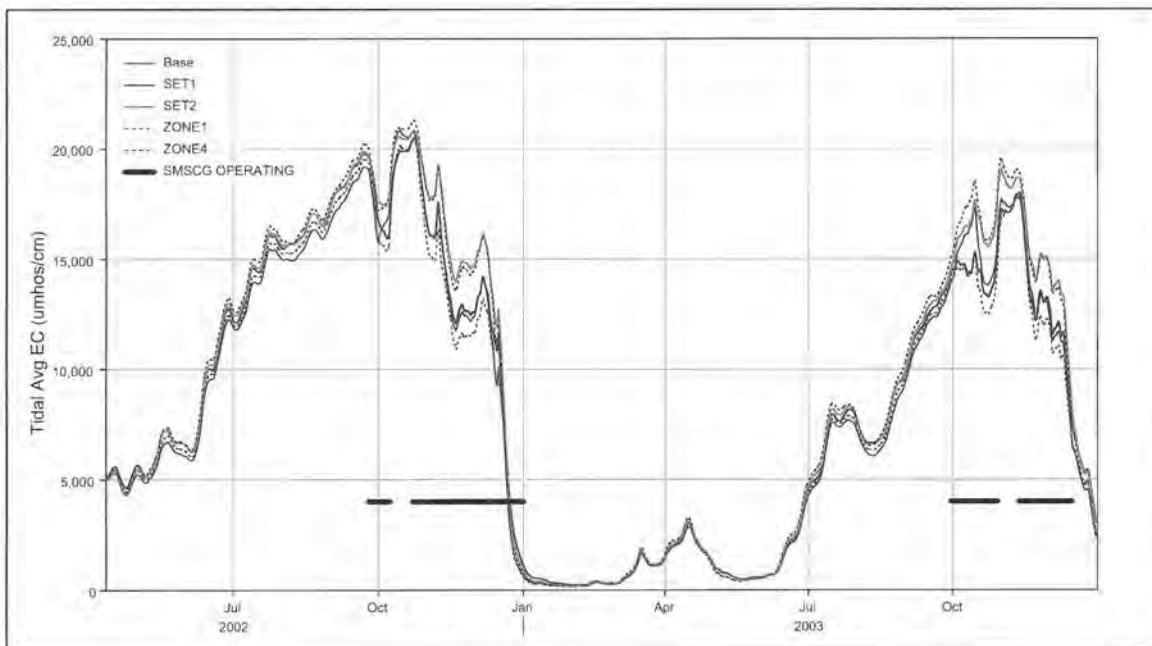


Figure 5-30 Tidally averaged observed and computed EC at station S-54 on Hunter Cut.

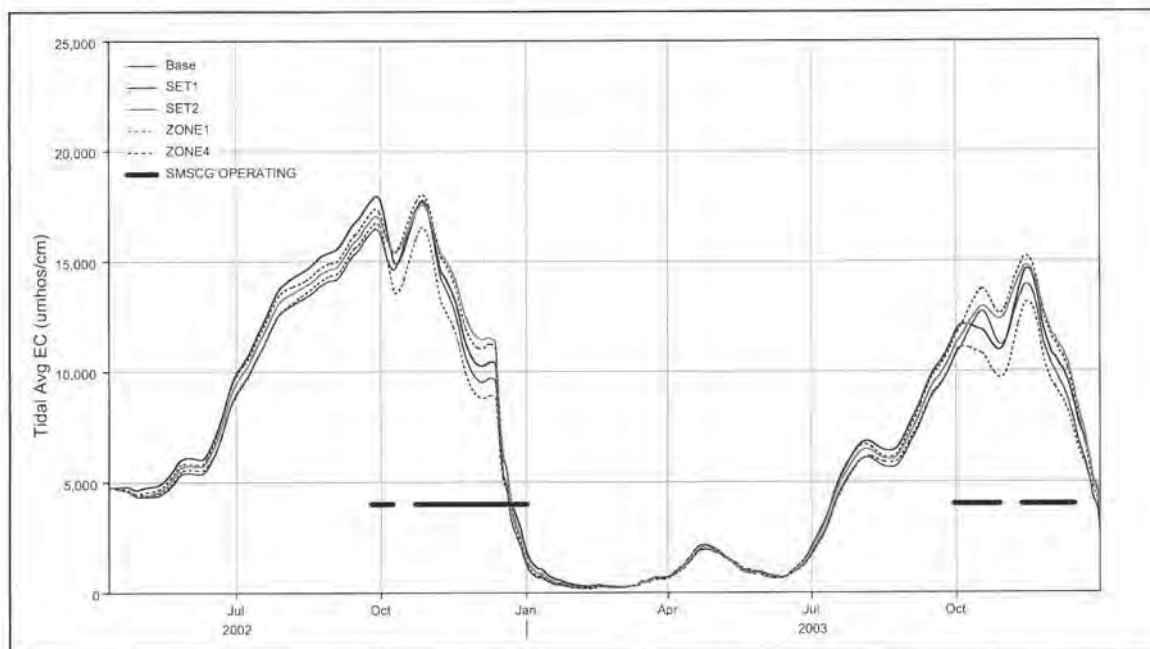


Figure 5-31 Tidally averaged observed and computed EC at station S-4 on Hill Slough.

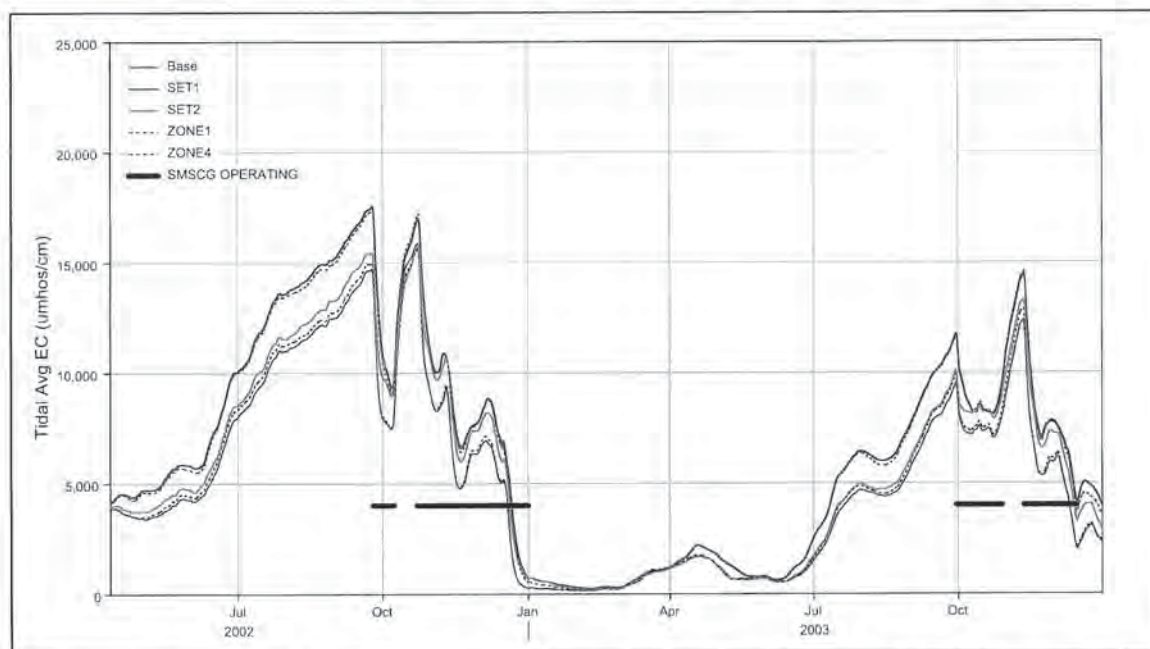


Figure 5-32 Tidally averaged observed and computed EC at station NS-1 on Nurse Slough.

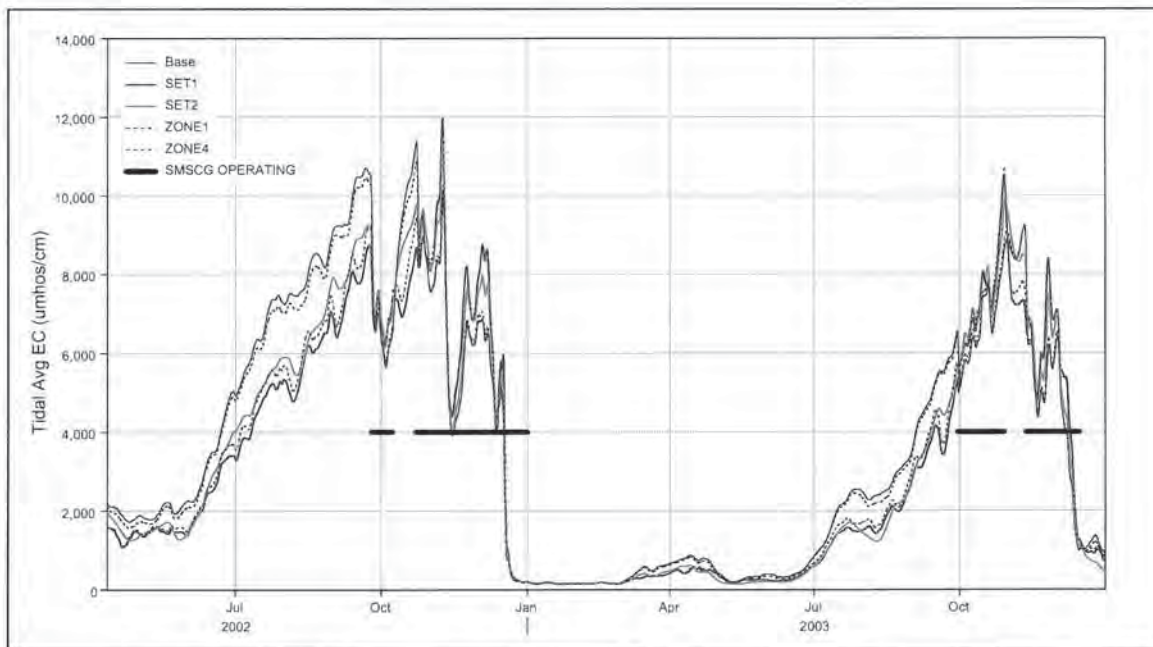


Figure 5-33 Tidally averaged computed EC at the S-64 monitoring location near National Steel on Montezuma Slough.

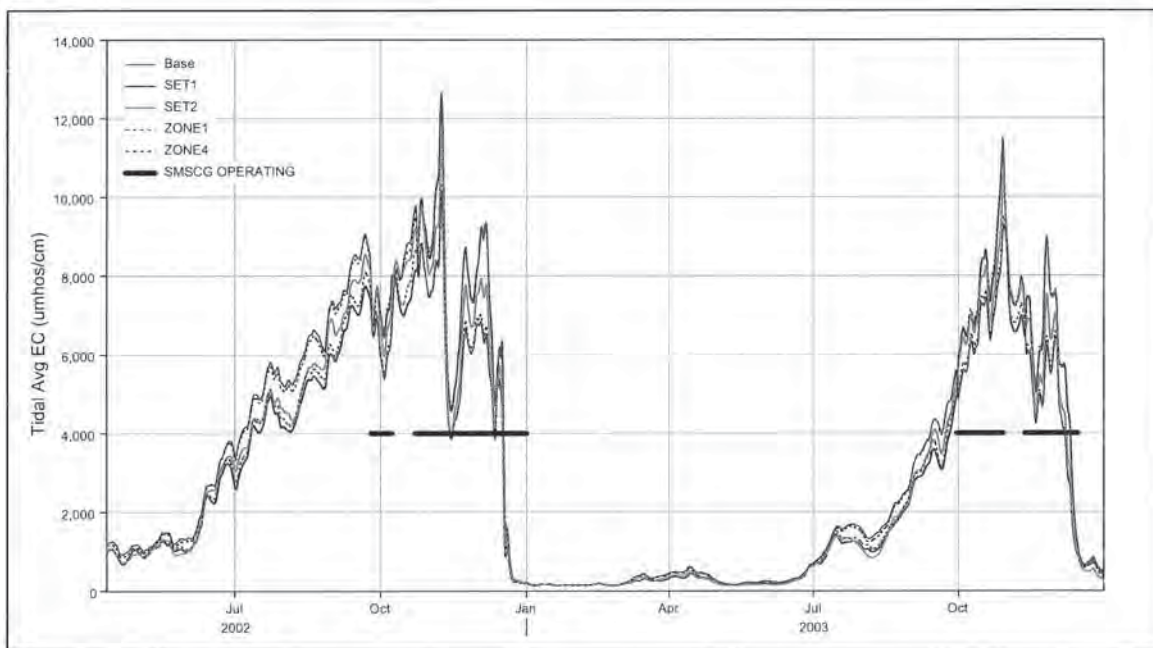


Figure 5-34 Tidally averaged computed EC at the S-71 monitoring location at Roaring River on Montezuma Slough.

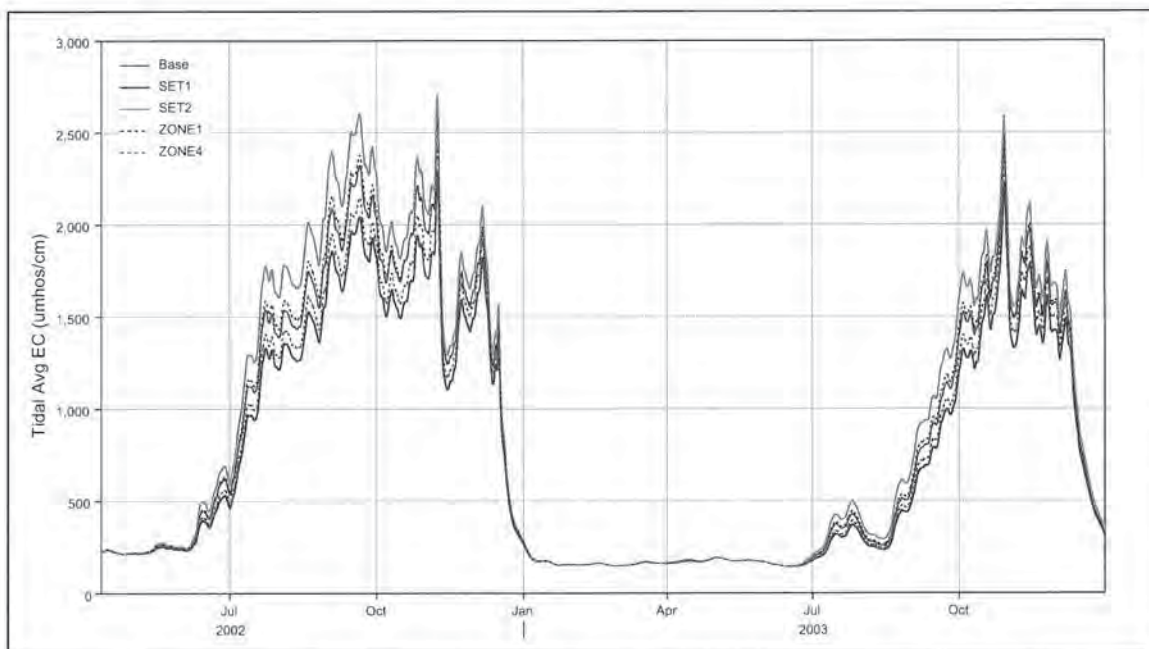
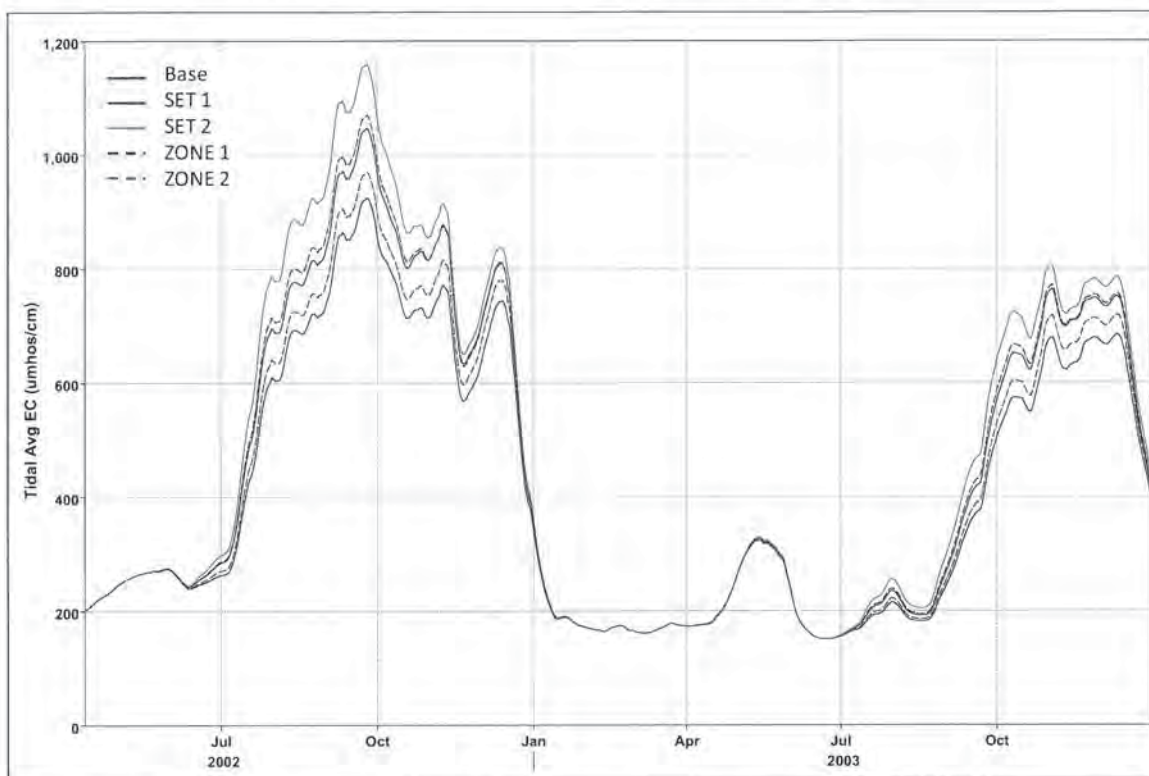
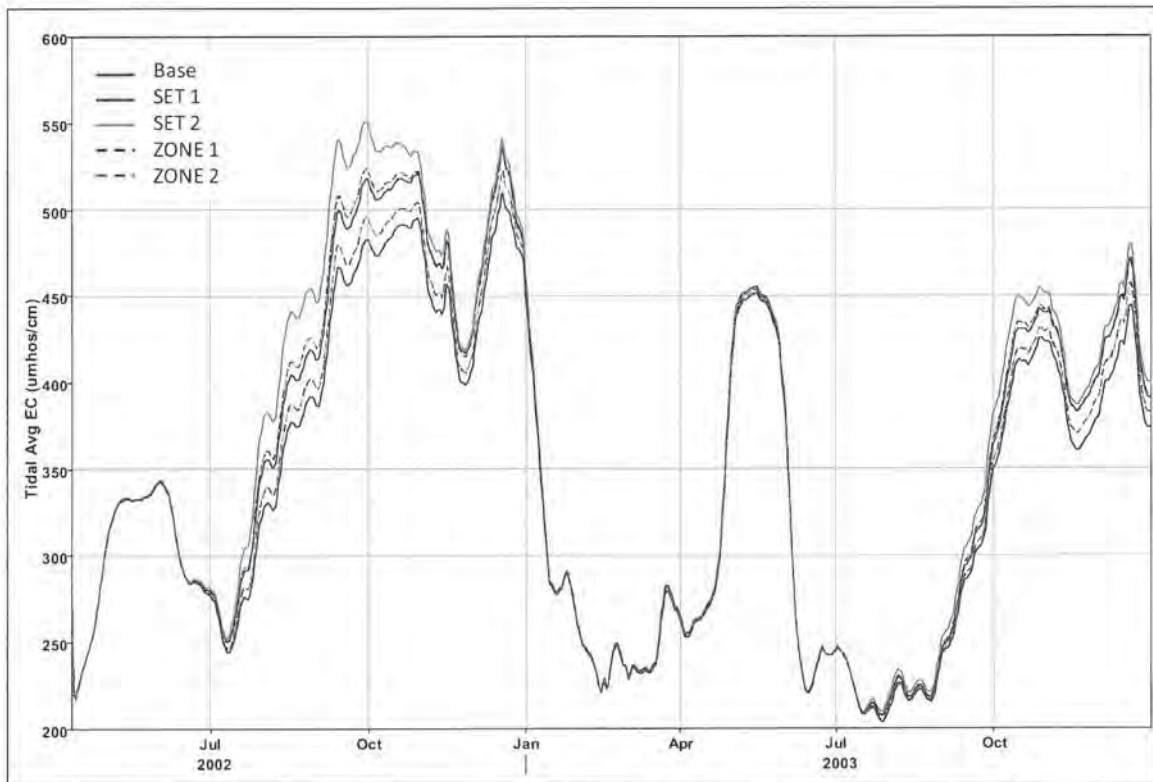


Figure 5-35 Tidally averaged computed EC time series at Jersey Point.



5-36 Tidally averaged computed EC time series at Old River at Rock Slough.



5-37 Tidally averaged computed EC time series at the CCWD Victoria Canal export location for Los Vaqueros.

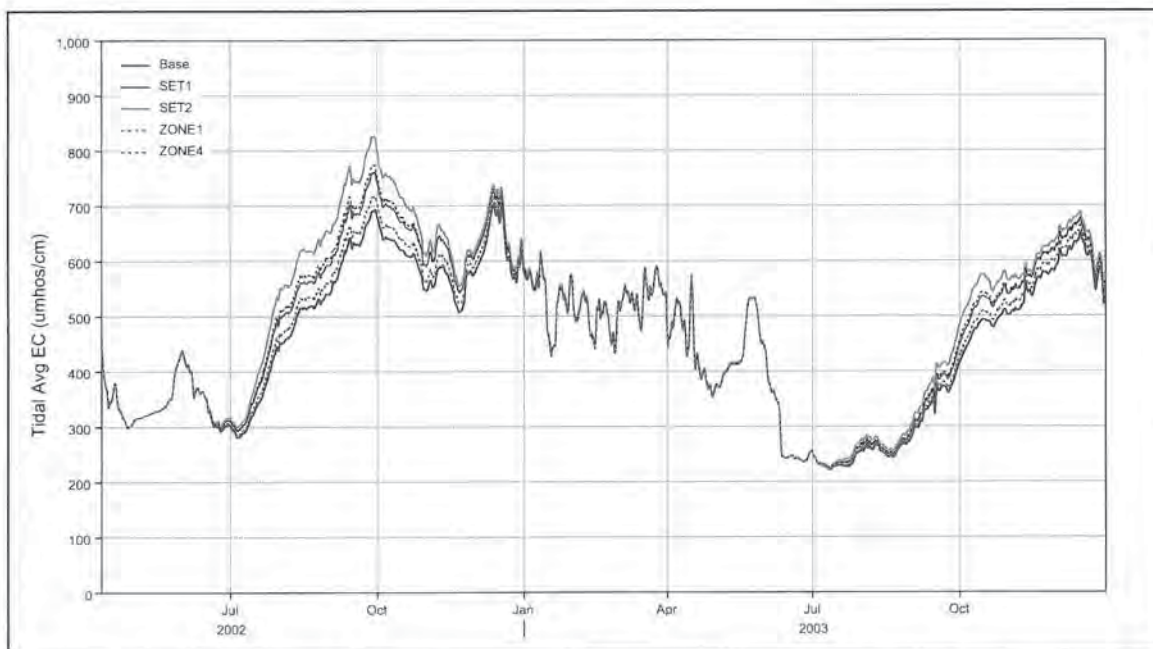


Figure 5-38 Tidally averaged computed EC time series at the CVP export location.

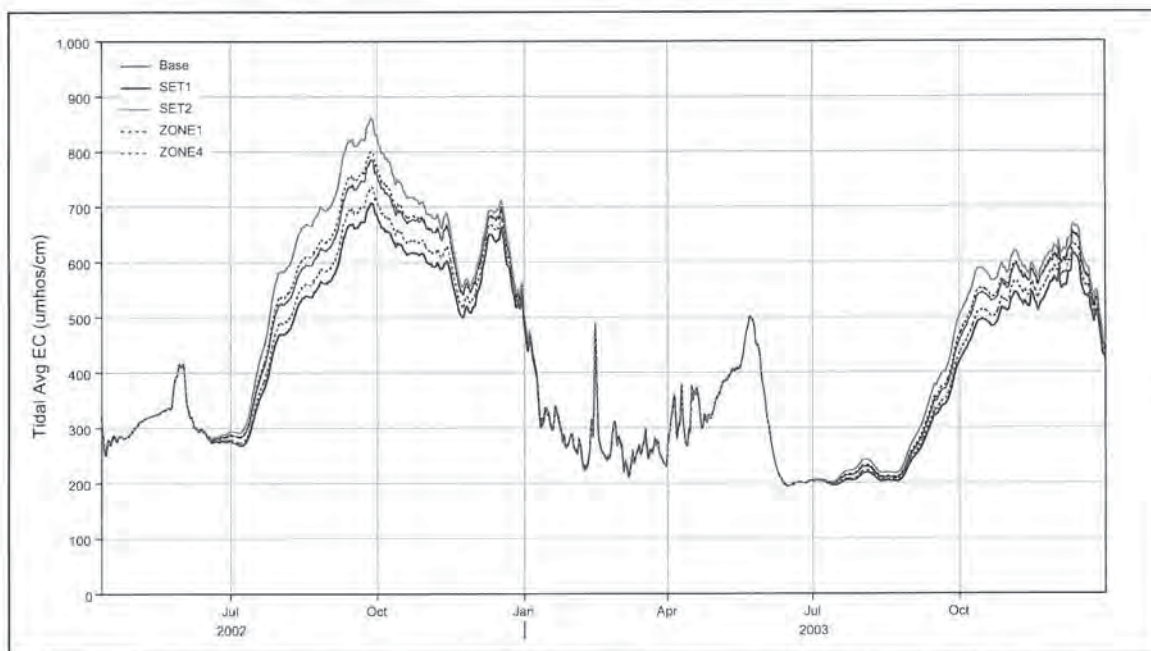


Figure 5-39 Tidally averaged computed EC time series at the SWP export location.

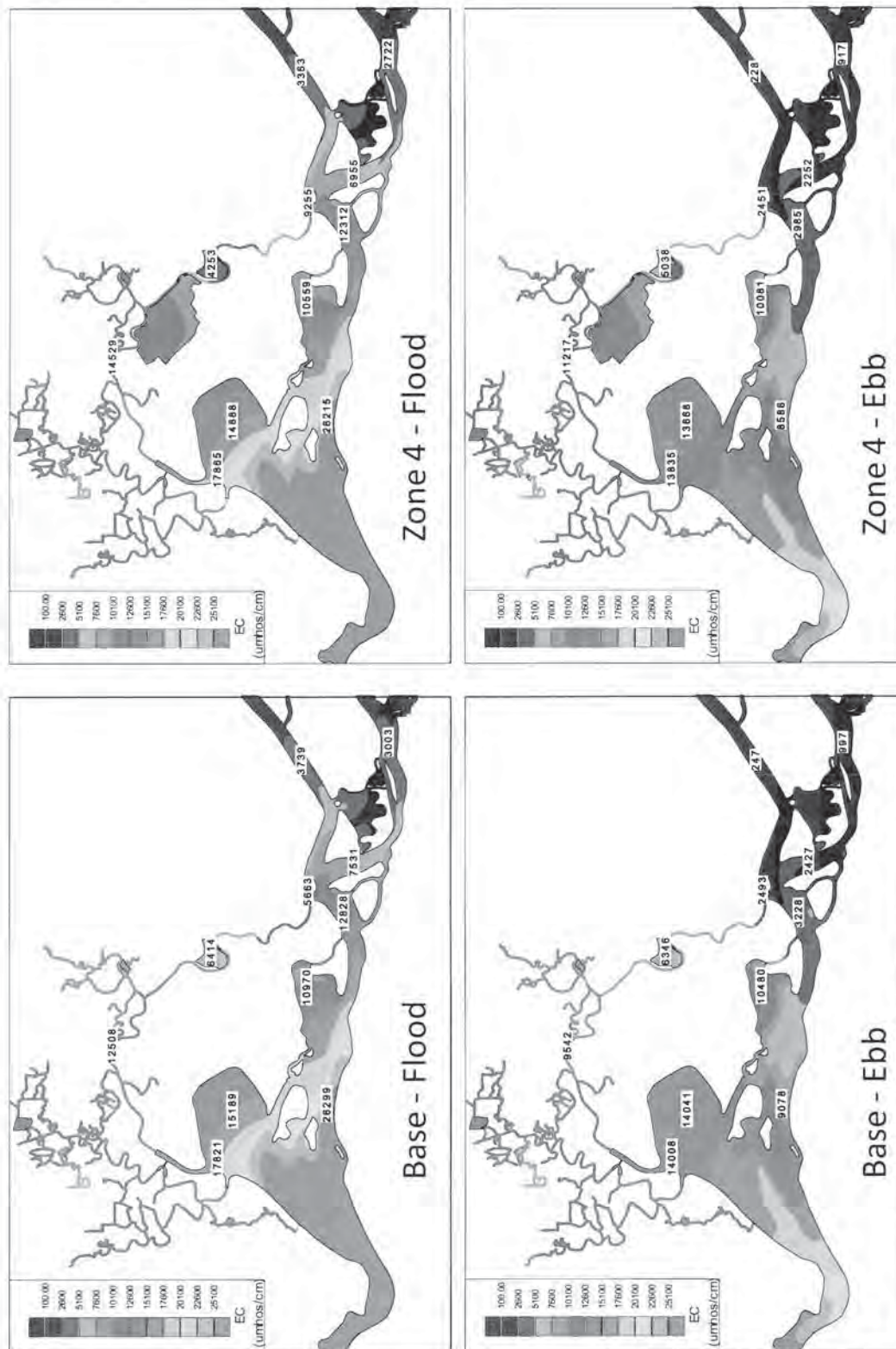


Figure 5-40 Color contour plots of EC for the Base case (left) and Zone 4 scenario (right) at the same timing on a flood tide (upper) and ebb tide (lower).





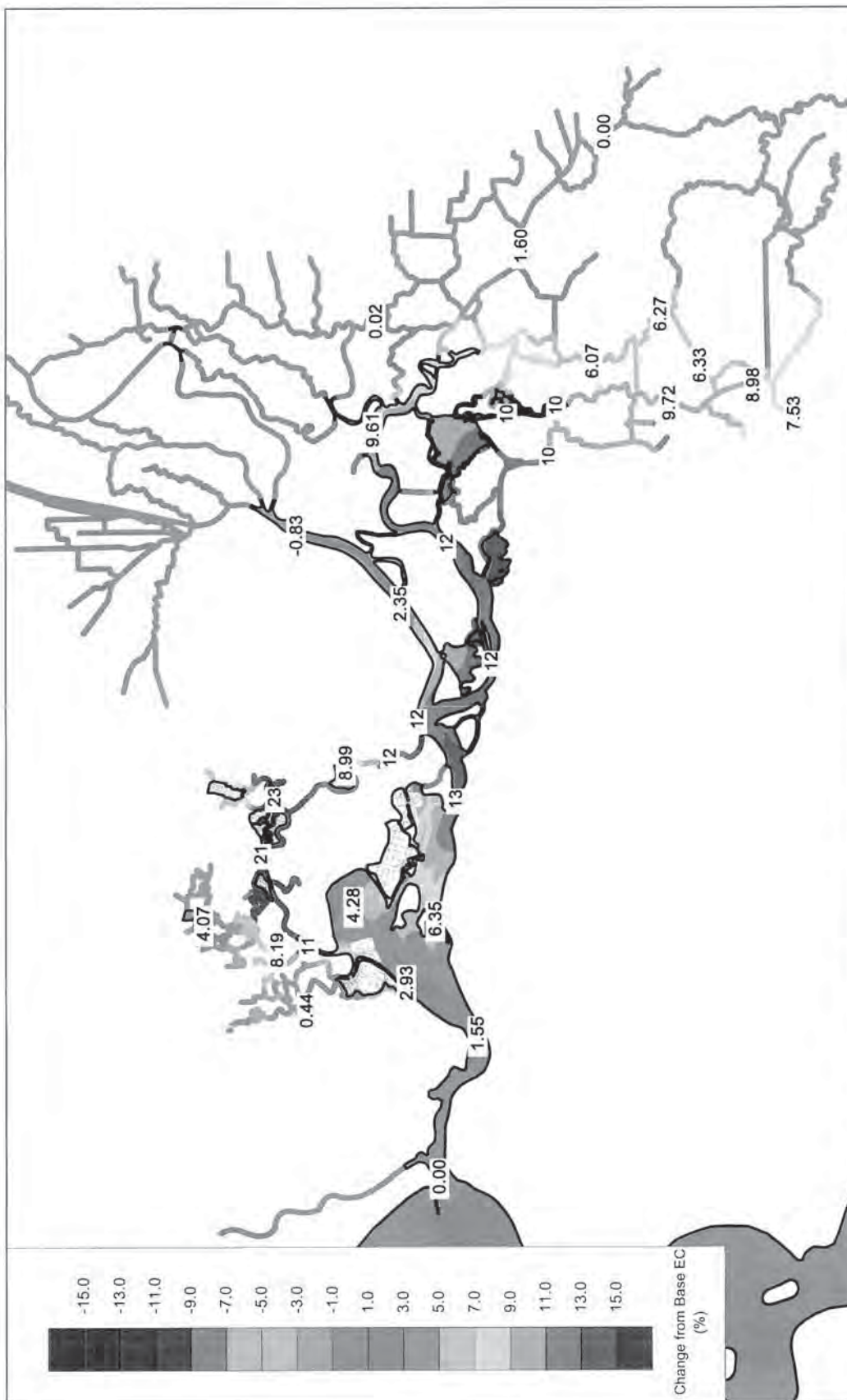


Figure 5-43 Set 2 EC % change from Base case – October 1, 2002.



Figure 5-44 Set 2 EC % change from Base case – September 1, 2003.



Figure 5-45 Set 2 EC % change from Base case – October 1, 2003.

Review of Delta Wetlands Water Quality Release and Generation of Dissolved Organic Carbon from Flooded Peatlands

K. R. Reddy
Wetland Biogeochemistry Laboratory
Soil and Water Science Department
University of Florida, Gainesville, FL 32611

Final Report –2005

In-Delta Section
Division of Planning and Local Assistance
Department of Water Resources
P.O. Box 942836
Sacramento, CA 94236-0001



Su ary

The CALFED Record of Decision (ROD) has identified five water storage projects in the upper Sacramento and San Joaquin River watersheds. The proposed In-Delta Storage project involves the conversion of existing islands in the Delta from agricultural land use to water storage reservoirs and wildlife habitat. Webb Tract and Bacon Island are proposed for water storage reservoirs, while Holland Tract and Bouldin Island will be developed for wildlife habitat.

A major environmental concern is that the re-hydration of organic rich peat soils in Delta islands will result in substantial release of dissolved organic carbon (DOC). The exchange of water from these reservoirs for urban use can potentially increase the export of dissolved constituents, especially DOC that form disinfection byproducts such as trihalomethanes, chloroform, and bromodichloromethane. Thus, it is important to quantify the sources and fate of dissolved organic matter (DOM) in these reservoirs, since major nutrients are associated with DOM.

This report presents: (1) a review of the methodology of mesocosm experiments conducted to determine DOC and TOC release from peat soils; (2) analysis of the consistency of the data collected; (3) conclusions that can be drawn from the data about the rate of DOC and TOC release into water column; (4) limitations of the data and its use; and, (5) recommendations on the approach used and additional work required to improve the predictability of DOC and TOC release.

Mesocosm experiments were conducted to determine DOC and TOC flux rates from soil to overlying water column. The first set of experiments was conducted in 1999-2000. Tanks were repacked with peat soil from Bacon Island and new experiments were initiated in 2002 and continued until 2004. During these three years, hydraulic operation modes were different, which made it difficult to compare results of DOC and TOC flux rates.

Data presented in the DWR reports are adequate, but additional analysis of the data is needed. There were some inconsistencies with the analysis of 2003 DOC data. These data were reanalyzed by accounting for the mass DOC removed during water exchange periods. The DOC and TOC loading rates for all years were computed using the data provided by DWR staff.

Conclusions drawn in the reports on DOC and TOC release are generally acceptable. The data analysis primarily produced average DOC and TOC loading rates for the whole study period. No consideration was given for the temporal effects on DOC release. Further analysis of the data showed a positive relationship between ambient air temperature and DOC flux rates.

The DOC accounted for approximately 93 to 98% of TOC in mesocosm water column, while under field conditions (Jones Tract flooding) the DOC accounted for 84% of the TOC. Average DOC flux rate was 0.6 g/m² day in 2002, decreased to 0.4 g/m² day in

2003, and $0.15 \text{ g/m}^2 \text{ day}$ in 2004. When compared to 2002 data, flux rates decreased by approximately 40% in 2003 and by 70% in 2004. These results suggest that the initial “tea bag” effect sustains for approximately 2 years.

Flooding of Jones Tract agricultural lands resulted in substantial release of DOC and TOC into the water column. During the first 48 days of flooding, DOC and TOC flux rates were $0.48 \text{ g/m}^2 \text{ day}$. This rate was similar to those observed in 2002 mesocosm experiments.

The data collected in mesocosm experiments was adequate to estimate the DOC flux rates. However, the data collected is not adequate to explain changes and dynamics of DOC fate in these systems. Operation of mesocosms should be continued for another 2 years to determine the steady state. Operation mode of the mesocosms should be maintained in a consistent manner. Sampling frequency should be increased to determine the true temporal variability. At the minimum, samples should be analyzed for TOC.

Data on physico-chemical environment of the water column is needed. At the minimum dissolved oxygen, temperature and conductivity of water column should be monitored.

Some effort should be placed to identify sources, chemical nature, and the fate of DOC in the water column (see the last section in the report for additional data needs).

A field study is more appropriate to determine more realistic DOC/TOC loading rates. Mesocosm experiments provided the first approximation of the DOC loading rates, but the rates may be lower under field conditions. Mesocosms functioned more as static systems and lack hydrodynamic events that would occur under field conditions.

Introduction

Peatlands or organic soils (histosols) are naturally productive and contain large amounts of organic carbon (C), nitrogen (N), sulfur (S), and phosphorous (P). These soils are poorly drained and have high water holding capacities. In many areas of the United States, these organic soils were formerly wetlands, which were drained for use in agriculture. Globally, peatland area is estimated to be in the range of 388 to 408 million hectare (ha), and approximately 25 million ha of peatland has been drained and developed for agriculture and forestry (Armentano and Verhoeven, 1988). Peatlands have become a vast global carbon pool, holding approximately 390 gigatons of terrestrial carbon or 28% of the global soil carbon stock (Jenkinson et al., 1991). A classic example, is the drainage of more than one million acres of organic soils in South Florida for use in agriculture (sugarcane, vegetables, and other crops). Because these soils have high water holding capacity, they are artificially drained when used for agriculture and the drainage water is often pumped into adjacent wetlands and aquatic systems. Overall loss of peat soil as a result of biological oxidation and subsidence was estimated to range from 1.4 to 2.54 cm/year (Shih et al., 1997), subsidence rates up to 3.4 cm/year were observed in New Zealand peatlands (Schipper and McLeod, 2002). Drainage of these soils produces substantial amounts of dissolved organic and inorganic nutrients, causing serious environmental concern.

Agricultural lands adjacent to ecologically sensitive aquatic systems are now being acquired by state and federal agencies, and in many cases, these areas are converted back to their natural conditions. Many of these lands were once intensively used for agriculture with continuous application of fertilizers and pesticides for a number of years. The first step in the restoration efforts of these lands is the re-establishment of hydrology through flooding in an attempt to convert them into wetlands. Initial flooding of these lands poses potential water quality problem as the dissolved nutrients stored in these soils are rapidly released into the water column. With time after flooding, hydrophytic vegetation becomes established with macrophyte communities such as *Typha*, *Sagittaria*, *Polygonum*, *Panicum*, *Pontedaria*, and others, and may aid in reducing the dissolved constituents through uptake and breakdown. Similarly, the proposed In-Delta Storage Project (IDSP), which involves conversion of four Delta islands for water storage and wildlife habitat, will need to address the environmental concern.

The CALFED Record of Decision (ROD) identified five water storage projects in the upper Sacramento and San Joaquin River watersheds. The proposed In-Delta Storage project involves the conversion of existing islands in the watershed from agricultural land use to water storage reservoirs and wildlife habitat. Webb Tract and Bacon Island are proposed for water storage reservoirs, while Holland Tract and Bouldin Island will be developed for wildlife habitat (DWR, 2003). Soils of the all project sites are histosols, with organic carbon content greater than 12%. Water will be diverted into reservoirs during winter months when flows are high, while water will be released into Delta channels during summer months when flows are low and demand is high. A major environmental concern is that the re-hydration of organic rich peat soils in Delta islands will result in substantial release of dissolved organic carbon (DOC), dissolved organic

and inorganic forms of nitrogen and phosphorus. Thus exchange of water from these reservoirs for urban use can potentially increase the export of dissolved constituents, especially DOC and its role in formation of disinfection byproducts such as trihalomethanes, chloroform, and bromodichloromethane. Thus it is important to quantify the sources and fate of dissolved organic matter (DOM) in these reservoirs, since major nutrients are associated with DOM. This report focuses primarily on DOC and TOC release rates from soil to the overlying water column.

Shallow reservoirs and wetlands are characterized by abundant and diverse sources of organic matter including the inputs of allochthonous sources of organic matter (from adjacent watersheds) and autochthonous sources (planktonic and macrophyte photosynthesis). Organic matter in these systems is present as dissolved organic carbon

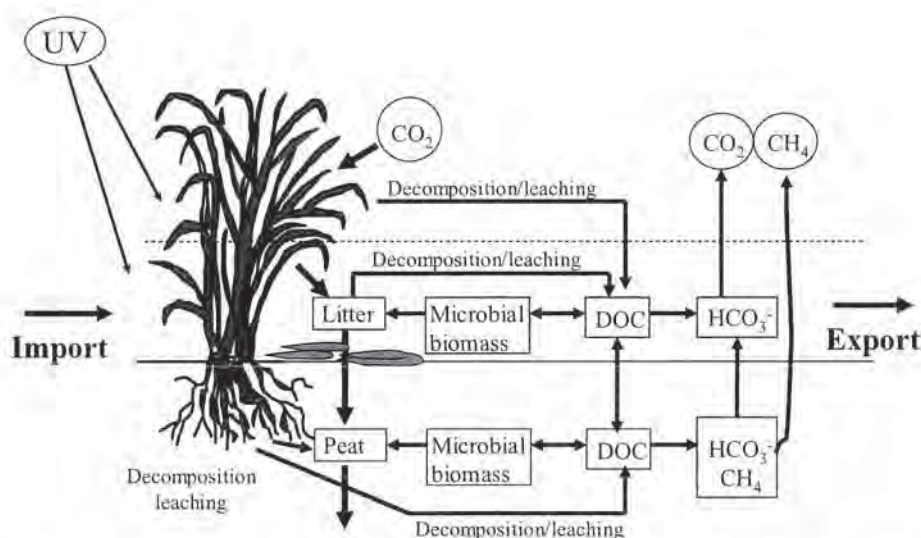


Figure 1. Organic carbon cycling in a flooded peatland. Litter, peat, and microbial biomass are considered as particulate organic carbon (POC).

(DOC) and particulate organic carbon (POC) (Figure 1). Both of these fractions are derived from dead plant tissue produced within the system, native soil organic matter or exported from adjacent ecosystems. The biogeochemical characteristics of allochthonous organic matter loaded to wetlands may vary spatially and temporally, depending on watershed management. For example, organic matter derived from silvicultural operations will have different chemical characteristics than the organic matter exported from watersheds dominated by agriculture. In addition to spatial variations in organic matter sources, temporal variations can occur as result of dynamic nature of aquatic systems.

Wet precipitation can be considered as allochthonous source of DOC to reservoirs. The DOC concentrations in precipitation range from 0.6 to 7.6 mg/L. Dissolved organic carbon fluxes from precipitation vary with values in the range of 0.3 to 8.9 g C/m² year in North America, 1.9 to 3.9 g C/m² year in tropical islands, 1.3 to 4.8 g C/m² year in South America, 1.4 to 5.8 g C/m² year in Europe, 3.4-3.5 g C/m² year in Australia, and 1.1 g C/m² year in Africa (Aitkenhead-Peterson et al. 2003). A wide range of DOC fluxes (1-

84 g C/m² year) from terrestrial ecosystems (forests, grasslands, peatlands) have been reported (Aitkenhead-Peterson et al. 2003). In a recent study, Freeman et al (2004a, b) observed a 65% increase in the DOC concentration of freshwater draining from upland watersheds in the United Kingdom over the past 12 years. These researchers attribute the increase in DOC to an increase in the activity of phenol oxidase, an enzyme believed to regulate carbon storage in peatlands. They showed increase in temperature had significant effect on the activity of phenol oxidase. A 10° C rise in temperature (in the range of 2° to 20° C) resulted in 36% increase in activity and was also accompanied by an equivalent increase in the amount of DOC released (Freeman et al., 2004a,b).

In water storage reservoirs created on peatlands, autochthonous DOC of algal and macrophyte origin can be an important contributor to the total DOC pool. The relative importance of these two sources (algae and macrophytes) depends on water depth, nutrient status, and physico-chemical environment in the water column. During active growth, both algae and macrophytes release a significant proportion of their primary production as DOC. The DOC produced from these sources consists of low-molecular weight compounds, is biologically labile and readily used as an energy source by microorganisms (Stuart et al., 2003).

The ecological significance of DOC is poorly understood and has not been clearly defined. This is mainly due to lack of a clear understanding of the composition of the DOC and its biodegradability. The DOC may represent a broad spectrum of organic compounds of varying environmental recalcitrance; thus it may not be possible to treat DOC as a homogeneous category. Both DOC and POC involves both labile and non-labile (recalcitrant) organic matter, the latter comprising the major fraction. Turnover of

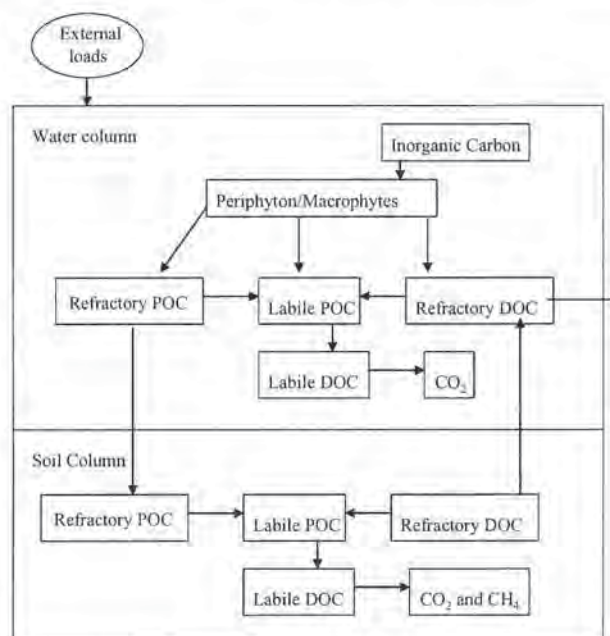


Figure 2. Carbon pools in flooded peatlands

highly labile, energy rich organic substrates may approach a rate of 5-10 times per day; thus actual concentration of the labile organic fraction may be extremely low. Despite the fact that recalcitrant DOC and POC are slow to mineralize, these pools represent a major portion of the organic matter processed by the heterotrophic community due to the relatively massive size of these pools (Figure 2).

The DOC in the mixture of organic material in DOM can be separated into two broad categories: humic and non-humic substances. The non-humic substances contain simple organic compounds such as proteins, carbohydrates, lipids, waxes, and low molecular weight organic acids. These highly labile materials are generally of low molecular weight (<500 Da) and are readily degraded. Humic substances are typically high molecular weight (500 to over 10,000 Da), more recalcitrant and often impart a yellow or black color to natural waters.

The majority (>95%) of organic matter in aquatic ecosystems is composed of polymeric, high-molecular weight compounds. These high-molecular weight compounds must be broken into simple, low-molecular weight compounds, before microbes can utilize them. The high-molecular weight compounds are too large to pass through microbial cytoplasmic membrane. This means the majority of the POC and DOC may not be readily available (Chrost, 1990). In a natural environment, these polymeric organic substrates undergo stepwise enzymatic depolymerization and hydrolysis. Many heterotrophic bacteria are excellent producers of these hydrolytic enzymes. Enzymatic hydrolysis is often considered as the rate limiting step in overall breakdown of DOC and POC in aquatic environments (Chrost, 1990; Wright and Reddy, 2001).

Photolysis has recently been investigated in wetland environments as one of the controlling mechanisms for degradation DOC. Photodegradation of DOC increases the labile carbon pool, which stimulates microbial activity (De Haan 1993). The UV region of solar radiation (280 to 400 nm) is most active in breaking down DOC (Moran and Zepp 1997). Wetzel et al (1995) described photolysis of littoral detritus as increasing availability of simple carbon substrates for bacterial metabolism. They concluded that though UV can photolyze complex organic matter to more available carbon forms, solar radiation can also limit activity of bacteria and plankton populations. Nevertheless, photolysis provides a continual-decay pathway for recalcitrant organic carbon (humic substances) into bioavailable forms of DOC. Most humics are chromophoric in that they absorb UV radiation and can undergo photolytic degradation. Although many reports view that the photochemical degradation of DOC as a mechanism for carbon transfer to the microbial food web, new observations are emerging to explain positive and negative effects on bioavailability. These positive and negative effects have been related to source of DOC. For example, photolysis effects on DOC derived from algae, phytoplankton, and macrophytes may result in condensation reactions of low molecular weight compounds into refractory macromolecules such as formation of humic substances (Harvey et al. 1983). In contrast, older DOC derived from macrophytes may consist of aromatic compounds which may be subjected to breakdown during photochemical reactions, making this DOC more biologically available (Moran Covert, 2003). Partial photolytic breakdown of humic substances results in generation of fatty acids and other related simple organic compounds that can serve as energy sources for microbes.

However, photolysis of humic substances can result in complete breakdown to CO₂ with the result of some inorganic nutrients.

After enzyme hydrolysis or photolytic breakdown, small molecular weight compounds are taken up and utilized as C and energy sources by heterotrophic microorganisms. A multitude of different microorganisms may be involved in this terminal step of decomposition, which depends largely on availability of electron acceptors. Diverse types of microorganisms couple oxidation of organic C substrates (electron donors) and reduction of electron acceptors to energy (ATP) production required for growth. The most common electron acceptors include O₂, NO₃, Mn⁺⁴, Fe⁺³, SO₄²⁻, and CO₂, that are gained through both internal and external inputs (Reddy and D'Angelo, 1994). For example, internal inputs include oxidation of chemical species (NH₄, H₂S, Fe⁺², and Mn⁺²) that diffuse from anaerobic to aerobic soil zones. External inputs of electron acceptors include atmospheric O₂, seawater (SO₄), surface water runoff (NO₃), and precipitation. Most wetlands contain several electron acceptors, so there exists competition for electron donors between microbial groups. Aerobic organisms are more efficient in breaking down DOC than anaerobic microbes. Thus, oxygenation of the water column can potentially decrease the DOC concentration.

Several physical, chemical, and biological transformations in soil and water column may result in breakdown of plant detritus and soil organic matter and export dissolved and particulate organic C. However, a large portion of detrital organic matter is buried via accretion, which provides a means for long-term storage of contaminants associated with organic C, such as nutrients (N and P), metals, and toxic organics. Depending on environmental conditions, stored nutrients and other contaminants may be released from the organic matrix through mineralization and then cycled through the ecosystem or exported from the system. As the detritus tissue C and N are cycled through a wetland at various stages of decomposition a portion can be lost as gaseous end products. Fate of DOC in aquatic ecosystems has been extensively studied as reported by Stuart et al. (2003).

A major component of the feasibility study is to assess the water quality impacts of the proposed IDSP, especially with respect to organic carbon concentrations from releases of stored water from the IDSP reservoir islands. This report presents: (1) a review of the methodology of a mesocosm experiment conducted to determine DOC release from peat soils; (2) analyze the consistency of the data collected; (3) conclusions that can be drawn from the data about the rate of DOC release into water column; (4) limitations of the data and its use; and (5) recommendations on the approach used and additional work required to improve the predictability of DOC release.

Specific tasks to be addressed in this report are:

- Review the information pertaining to the mesocosm experiments (often referred as water quality field investigations) contained in the reports provided by DWR .
- Review data and experimental procedures for consistency and determine if data are expressed in terms that are comparable and if not, determine if data can be

standardized to allow for comparison of like units. If standardization is necessary, standardize the data.

- Review the Jones Tract water quality data and estimate DOC release rates.
- Prepare a draft report that contains findings and recommendations concerning the use of the experiment and include discussion of (1) whether the data contributes to the understanding of annual, seasonal and shorter or longer term loading rates of organic carbon in flooded peat soil Delta environments, (2) the consistency of the data and analytical procedures, and (3) limitations of the data and its use.

The Department of Water Resources (DWR) provided the following information for review:

- Water sample results for all constituents measured, 2002 present
- Department of Water Resources, Draft Water Quality Report, In-Delta Storage State Feasibility Studies – December 2003.
- Department of Water Resources, In-Delta Storage Program State Feasibility Study CALFED Science Panel Review. August 2003.
- Department of Water Resources, In-Delta Storage Program Planning Studies, Water Quality evaluations, May 2002.
- Duval, Robert, Draft Research Paper.
- Duval, Robert, Experiment Data Collection Notes.
- Reddy, K. R., Review of Delta wetlands water quality modeling for release and regeneration of dissolved organic carbon, Final Report, 2002.
- Jones Tract Water Quality data, 2004.

Review the information pertaining to the mesocosm experiments (often referred as water quality field investigations) contained in the reports provided by DWR

2002 Mesocosm Experiments – Methods

Mesocosm studies were initiated in March 2002 at the Municipal Water Quality Investigations Field Support Unit in Bryte, California. Essentially, the mesocosms consist of four 3300 L (shallow) and four 6100 L (deep) fiberglass tanks (1.5 m diameter and 1.8 and 3.4 m height respectively). Peat soil depth in each mesocosm was set at 0.5 m. Soil used in mesocosms was obtained from Bacon Island, California, one of the proposed site for water storage reservoirs. Sacramento River water was used to fill tanks. Once filled, the depth water over the peat soil was approximately 1.4 m in the shallow mesocosms and 2.9 m in deep mesocosms. Tanks were filled in March and drained to 0.3 m depth in July. A control mesocosm (6100 L) with no soil was also included. Water samples were obtained once every two weeks and analyzed for several water quality parameters. Details of the experimental setup and water quality parameters can be found in DWR (2003).

2003 Mesocosm Experiments – Methods

In 2003 experiments, water column was replaced by filling thirds over a three months period starting January 2003. Winter filling and summer draining – typical reservoir operation was used. In addition approximately 15% of reservoir water volume was replaced every month. Water column was monitored for one year.

2004 Mesocosm Experiments – Methods

In 2004 experiments, operation of mesocosms was continued and water column chemistry was monitored for select water quality parameters.

Specific comments on methods used in mesocosm experiments are given below:

- The water quality data collected on mesocosms is adequate to estimate DOC loading rates and methods used followed all necessary QA/QC.
- Experiments conducted during 2002-04 lack consistency in terms of operational mode imposed on mesocosms. This made comparison of results made it difficult. The DOC loading rates estimated for each year should be interpreted in this context.
- Water and soil temperature data are not available to determine the relationships between DOC flux rates and temperature.

Mesocosm experiments – Results

The water column DOC data collected during 2002, 2003, and 2004 were used to estimate DOC release from soil to overlying water column.

Data on relationships between DOC and TOC are shown in Figure 3. The slopes of linear

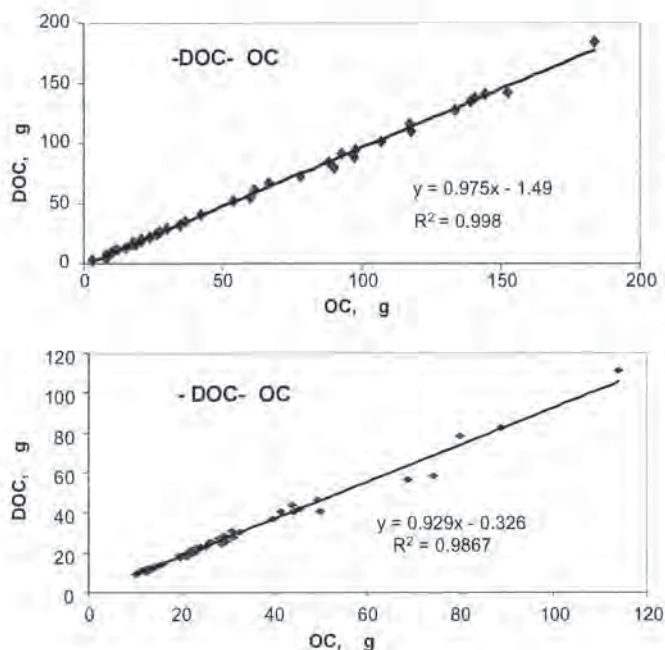


Figure 3. Relationship between dissolved organic carbon (DOC) and total organic carbon (TOC) in the water column during the year 2002 and 2003. Data points represent average values of four mesocosms for shallow and deep water depths.

3/15/2005

regressions (ratio of DOC/TOC) are 0.975 and 0.929, respectively, for 2002 and 2003. These ratios suggest that approximately 93 to 98% of the TOC is DOC. If the ratio between DOC/TOC is close to 1 (as shown in Figure 3) the data suggest that the source of DOC is from the underlying peat soil and possibly this DOC is slowly biodegradable. Low DOC/TOC ratio suggests that there is planktonic production of particulate organic carbon (POC) in the water column and rapid consumption of bioavailable DOC.

Under field conditions, it is very unlikely such a relationship exists. Typically under field conditions, POC is generated by plankton and other living biota in the water column. Low levels of POC in the water column suggest that the source of TOC to the water is primarily due to diffusive flux of DOC from underlying peat soils. Mesocosm water column are static systems with very little or no hydrodynamic events, such as wind induced circulation and mixing and resuspension of surface soils during heavy wind events. These systems at best represent potential DOC flux rates from soil to the overlying water column.

In 2002, mesocosms were filled on March 12 and water was stored until July 2002, simulating conditions of proposed reservoir operation. Water column DOC concentrations increased steadily from background levels to approximately 30 and 60 mg C/L at water depths of 2.9 and 1.4 m respectively (Figure 4). Low levels of DOC at

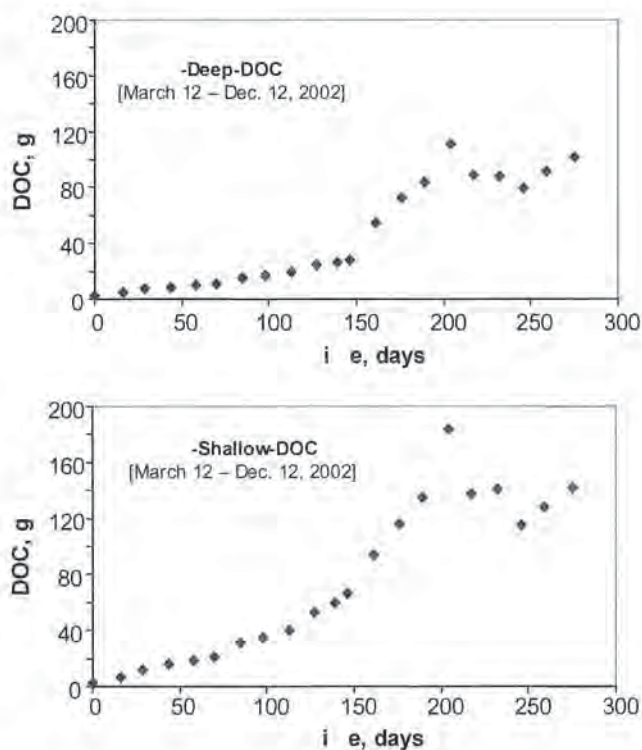


Figure 4. Dissolved organic carbon concentration in the water column of mesocosms during 2002. Deep water depth = 2.9 m; Shallow water depth = 1.4 m. Mesocosms were drained during the last week of July and operated at 0.3 m water depth during the

remainder of the year. Data points represent average values of four mesocosms for shallow and deep water depths.

higher water depth is primarily due to dilution. At the end of July 2002, mesocosms were drained to a water depth of 0.3 m and maintained at that level during the remainder of the year. Concentrations of DOC steadily increased to high levels in the range of 12 to 160 mg C/L. This is expected due to shallow water depth and concentration effects. During November and December, DOC concentrations leveled off as a result of dilution due to rainfall and slower release of DOC from peat soils. High DOC concentrations in the water column suggest that the soil porewater concentrations are substantially high resulting in flux from soil to overlying water column.

Cumulative mass DOC release from soil to overlying water column during 2002 is shown in Figure 5. Mass DOC release per unit area was calculated as follows:

$$\begin{aligned} \text{Mass DOC in the water column (g/m}^2\text{)} \\ = \text{Water column DOC concentration (g/m}^3\text{)} \times \text{water depth (m)} \end{aligned}$$

Mass DOC in the water column showed three distinct release rates. Slow release during the first two months (March and April) was probably due to start-up effects and low

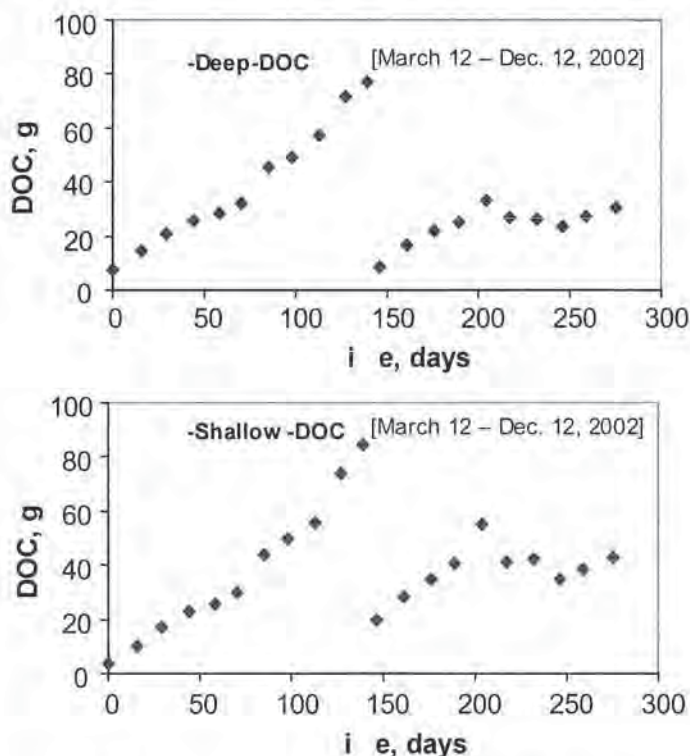


Figure 5. Mass DOC release into the water column of mesocosms during 2002. Deep water depth = 2.9 m; Shallow water depth = 1.4 m. Mesocosms were drained during the last week of July and operated at 0.3 m water depth during the remainder of the year. Data points represent average values of four mesocosms for shallow and deep water depths.

temperatures. During the months of May through July highest rates of DOC release rates were observed. This was followed by decrease in DOC release rates during the months of August and September. Water depth had minimal effect on DOC release rates during 2002.

During 2003 mesocosm mode of operation was changed by introducing new water circulation. Tanks were filled in thirds over a 3-month period starting in January 2003. After that period approximately 25% of the water was replaced with Sacramento River water once every month until August 2003. Complexity introduced in operation of mesocosms during 2003 experiments makes it difficult to compare results of earlier study conducted in 2002, which were operated as static systems. Exchange of water creates lower DOC concentration in the water column, which results in increased gradient between soil and overlying water column. Concentrations of DOC in the water column were in the range of 15 to 30 mg/L during February to July, 2003. In addition, exchange of water can also maintain higher dissolved oxygen levels in the water, thus increasing the overall biotic degradation of DOC. In the DWR Report, DOC mass release rates were calculated by normalizing DOC concentrations with measured water depth at the time of sampling. No attempt was made to account for mass of DOC removed during exchange periods. In the report provided (DWR, 2003) experimental and sampling

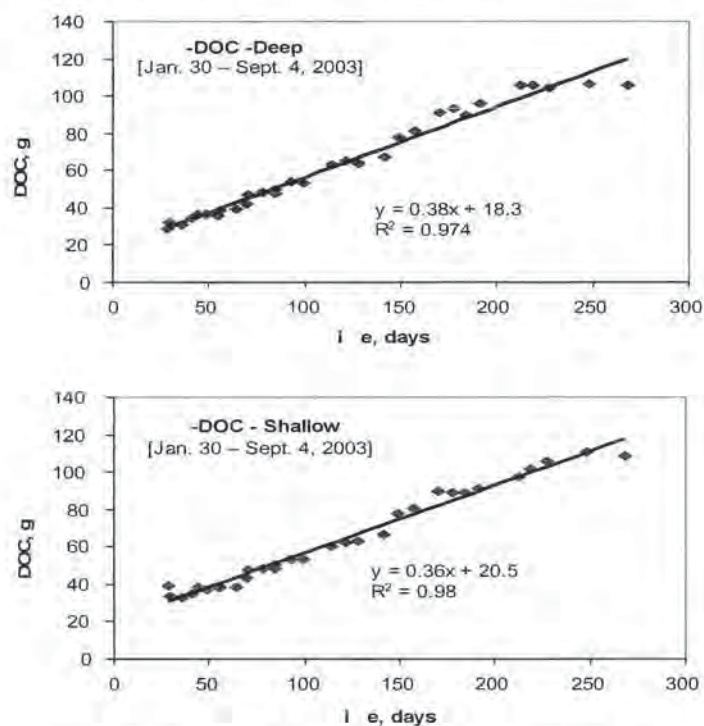


Figure 6. Mass DOC release into the water column of mesocosms during 2003. Deep water depth = 2.9 m; Shallow water depth = 1.4 m. Data points represent average values of four mesocosms for shallow and deep water depths.

protocols were not adequately described. Exchange of water probably added error to estimation of mass release rates. The DOC mass release rates (Figure 6) for each sampling step were calculated by accounting the amount of DOC removed during each water exchange cycle. Cumulative mass DOC release as function of time is presented. The DOC mass release rates in 2003 experiments were influenced by water circulation and seasonal temperature fluctuations. Adequate sampling was not done to determine true seasonal influences. However, bulk measurements as presented in Figure 6 suggest a linear increase in mass DOC release during the sampling period. Steady release in DOC was observed during the study period, with very little or no release during the first two months (January and February), and higher release observed during months May through August, reflecting the influence of temperature on DOC release. Results strongly suggest that DOC release is influenced significantly by seasonal fluctuations in temperature. Water temperature data are not available to develop the relationship between temperature and DOC release. Many biogeochemical processes are influenced by temperature, with reaction rates often doubled for every 10°C degree rise in temperature. Temporal variations in DOC flux rates are further discussed during the later part of this report.

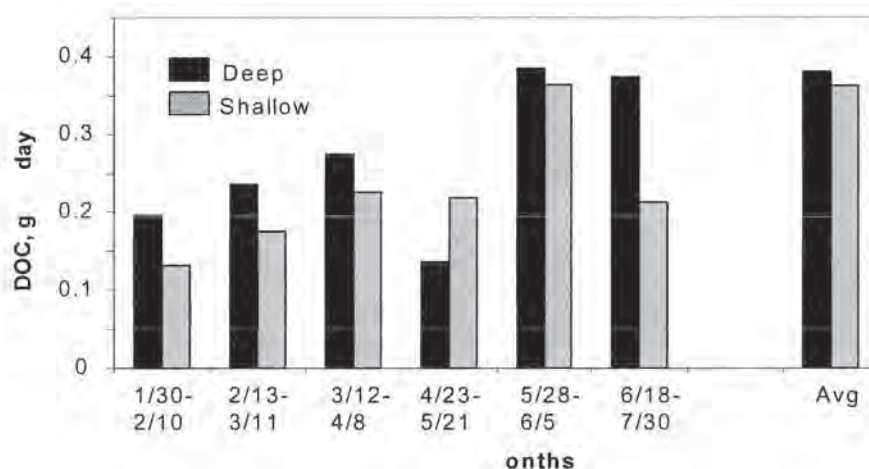


Figure 7. Mass DOC release rates between each water exchange periods during 2003. Deep water depth = 2.9 m; Shallow water depth = 1.4 m. Data points represent average values of four mesocosms for shallow and deep water depths.

The DOC mass release rates between each water exchange period were calculated to determine the influence of water exchange on DOC release (Figure 7). The estimated rates were influenced by errors associated with water exchange including dilution, measuring water depths, and seasonal temperatures. Adequate sample populations were not available between each sampling period, which may have added additional errors in estimating DOC flux rates. In general, shallow water depth tanks released slightly less DOC than the deep water depth mesocosms. However, these differences may not be significant. It is surprising to note that the DOC flux rates determined by the whole data set resulted in 0.37 g C/m² day. The rates measured between each water exchange period were lower or equal to the rates obtained for the whole experiment period. These results

suggest the flux rates measured between each water exchange period are underestimating the overall DOC flux. Experimental methods are not clear on how accurately water exchange mode of operation was accomplished and how well the water column was mixed during and between sampling periods.

In November 2003 mesocosms operation was changed again, this time by filling tanks to their respective depths of 1.4 and 2.8 m with Sacramento River water, with no water circulation. At the time of this report preparation, water column TOC data from November 2003 to June 2004 was available. During the experimental period, water depth was adjusted for evaporative losses. Earlier studies have shown that the DOC/TOC ratio of the water in mesocosm experiments is in the range 0.94 to 0.98. Thus the mass TOC release will be slightly higher than the DOC release observed in previous experiments. Concentrations of TOC in the water column were in the range of 7 to 12 mg/L at the start of the experiment and increase steadily to 15 to 30 mg/L. The TOC concentrations of the water in tank with no peat soil ranged from 2.5 to 4 mg/L. As described previously, DOC mass release rates were calculated by normalizing DOC

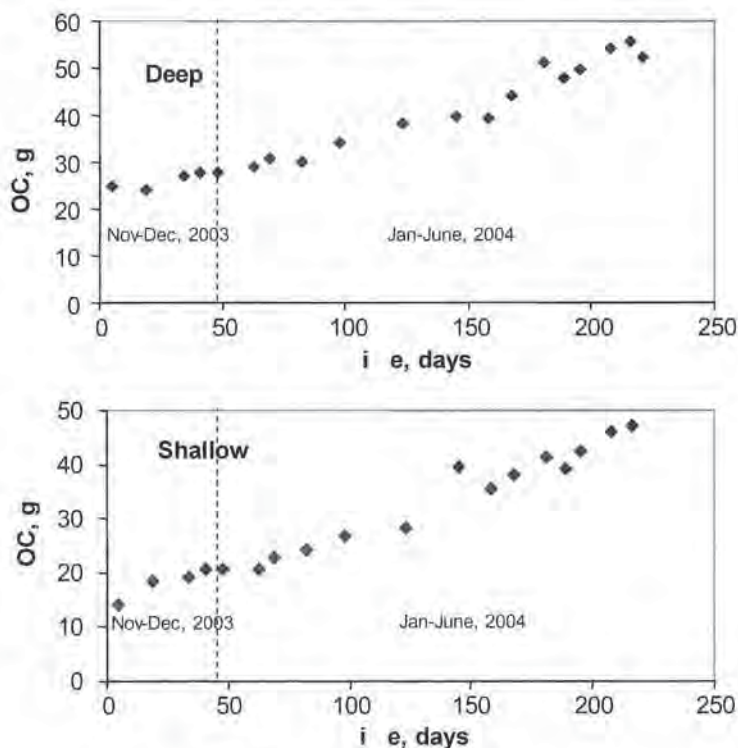


Figure 8. Mass DOC release into the water column of mesocosms during 2003-04. Deep water depth = 2.8 m; Shallow water depth = 1.4 m. Vertical dashed line represents January 1. Data points represent average values of four mesocosms for shallow and deep water depths.

concentrations with measured water depth at the time of sampling. Data on mass DOC release into water column are presented in Figure 8. The TOC release was slower during months of November 2003 to February 2004. Higher rates were observed during the

remainder of the study period (March –June, 2004). Mass release rates substantially decreased as compared to 2002 and 2003 experiments. At the end of the study (June 2004) TOC mass release was 50 and 52 g C/m² for 1.4 and 2.8 m water depths, respectively.

A summary of DOC and TOC flux rates estimated from mesocosm experiments from 1999 to 2004 are summarized in Table 1. Experimental conditions varied during each experiment. Experiments in 1999 and 2000 used various peat depths, flushing rates, and water depths. Mesocosms were reconstructed with new soil and constant peat depth of 0.5 m, but the experimental conditions varied during each year (2002, 2003, and 2004) study. For comparison purposes, we assumed that the experimental conditions imposed have minimal effect of DOC/TOC release from peat soil into water column. Last 3 years data shows the capacity of flooded peat soil to release DOC/TOC into water column.

Table 1. Dissolved organic carbon (DOC) and total organic carbon (TOC) release rates from flooded organic soils.

Experimental conditions	DOC Release Rate [g C/m ² day]	TOC Release Rate [g C/m ² day]
<i>DWR mesocosm experiments 1999 and 2000</i>		
Water depth = 0.6 m		
Tank 1 [0.46 m peat and no water exchange]	0.274	
Tank 2 [0.46 m peat and weekly water exchange]	0.684	
Tank 3 [0.92 m peat and no water exchange]	0.411	
Tank 4 [0.92 m peat and weekly water exchange]	0.767	
Water depth = 2.1 m		
Tank 5 [0.92 m peat and no water exchange]	0.093	
Tank 6 [0.46 m peat and weekly water exchange]	0.591	
Tank 7 [0.46 m peat and no water exchange]	0.123	
Tank 8 [0.92 m peat and weekly water exchange]	1.055	
<i>DWR mesocosm experiments</i>		
<i>2002 (March –December)- All tanks</i>		
2.9 m water column [March-July]	0.492	0.492
0.3 m water column [August-Sept.]	0.403	0.425
1.4 m water column [March-July]	0.554	0.554
0.3 m water column [August –Sept.]	0.574	0.573
<i>DWR mesocosm experiments - 2003 - All tanks</i>		
[January-August] – Shallow	0.362	
[January-August] - Deep	0.380	
<i>DWR mesocosm experiments</i>		
<i>2003 - All tanks [no circulation]</i>		
[November-December] - Shallow		0.142
[November – December] - Deep		0.087
<i>DWR mesocosm experiments</i>		
<i>2004 - All tanks [no circulation]</i>		
[January-June] - Shallow		0.150

For years 2002 through 2004 of the study, seasonal influences on DOC flux rates were estimated and the data are presented in Figure 9a, 10, and 11. Distinct seasonal effect on DOC flux was observed during all three years. Unfortunately, data were not collected consistently during all 3 years to determine true seasonal effect on DOC flux. For example, in 2002 experiments were initiated in March and useful data were collected until the end of September 2002. Data collected in October – December, 2002 were affected by rainfall. Highest DOC flux rates in 2002 were observed during July (Figure 9a). DOC flux rates were higher in mesocosms with 1.4 m water depth as compared to tanks with 2.9 m water

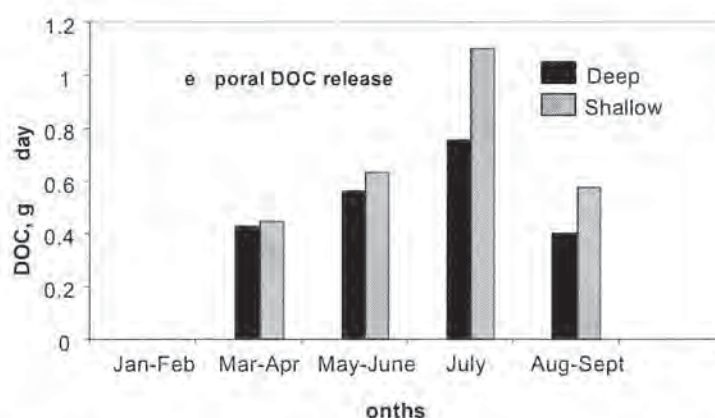


Figure 9a. Seasonal influences on DOC flux from peat soil to overlying water column during 2002. Deep = 2.9 m water depth; Shallow = 1.4 m water depth. Data points represent average values of four mesocosms for shallow and deep water depths.

depths. Maximum and minimum air temperatures at the Bryte site for 2002 are shown in Figure 9b. Highest maximum and minimum temperatures were observed during the month June – July. During these months DOC flux rates were also high. Trends in DOC flux rates reflect in temporal changes in temperature.

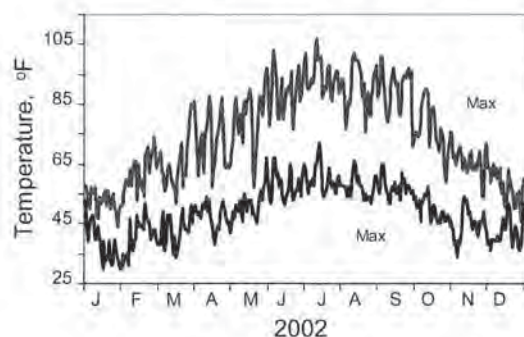


Figure 9b. Maximum and minimum air temperature at the Bryte site.

During the year 2003, water quality data was collected from January 1, 2003 to September 4, 2003. Seasonal rates were calculated based on regressions using the data on bimonthly basis and on a monthly basis. In addition to temporal variability, it should be noted that the rates were also influenced by water exchange periods. The DOC flux rates show, typical season patterns with rates lower during winter and higher during summer months. DOC fluxes steadily increased with no positive flux during January-February, and maximum flux during July and August months. In addition, during the 2003 experiments seasonal DOC fluxes were also influenced by variable water exchange rates.

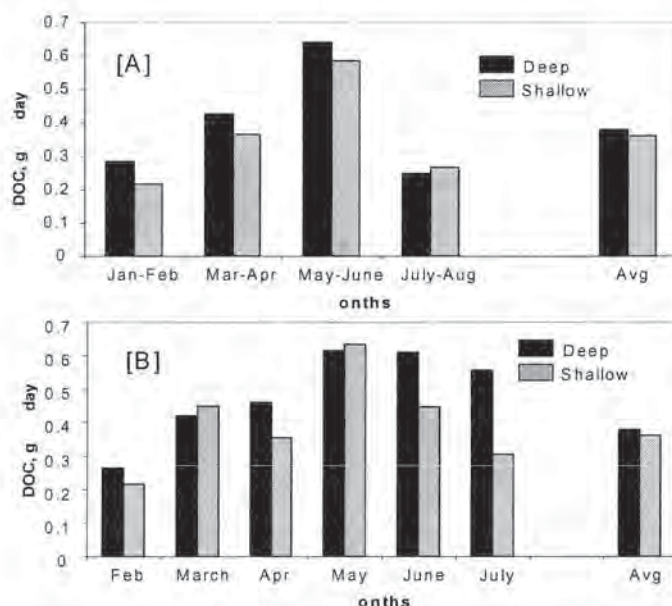


Figure 10. Seasonal influences on DOC flux from peat soil to overlying water column during 2003. Deep = 2.9 m water depth; Shallow = 1.4 m water depth. Data points represent average values of four mesocosms for shallow and deep water depths. [A] Rates calculated on bi-monthly basis. [B] Rates calculated on monthly basis.

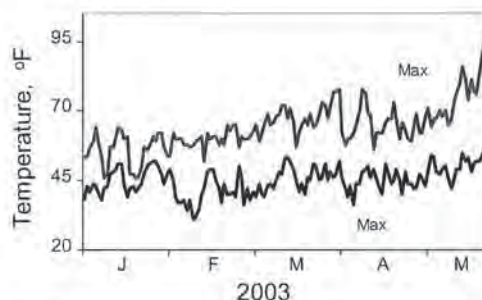


Figure 11. Maximum and minimum air temperature at the Bryte site during the months January to May.

At the time of preparation of this report, temperature data were available for the whole year of 2002 (Figure 9b) and for January-May in 2003 (Figure 11). To determine the

relationships between temperature and DOC flux rates, 2002 data were used for some of the months in 2003. Average daily ambient air temperature was calculated as follows:

$$\text{Average daily air temperature} = \frac{\text{sum } (T_{\max} + T_{\min})}{2t}$$

Where: $T_{\max}$ is the maximum daily air temperature; $T_{\min}$ is the minimum daily air temperature; t is the number of days used in calculation of DOC flux rates (bimonthly). The relationship between DOC flux rates and the average daily air temperature is shown in Figure 12.

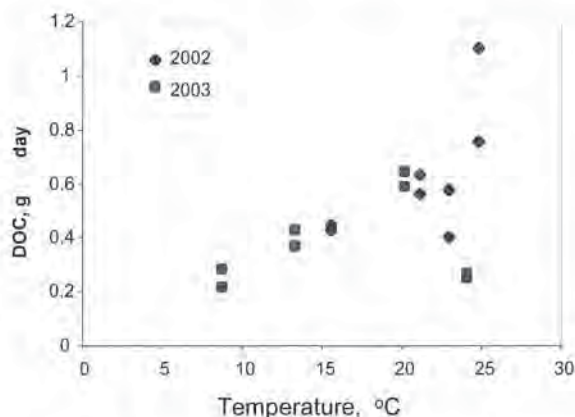


Figure 12. Relationship between ambient average air temperature and the DOC flux rates for the year 2002 and 2003. DOC flux rates estimated on a bimonthly basis.

With the exception of two data points, there exists a positive relationship between ambient average air temperature and DOC flux rates. The flux rates approximately doubled with 10° C rise in temperature, suggestion a Q_{10} value of 2. Sampling frequency was not adequate enough to develop strong relationships. However, Figure 12 shows strong temperature effects. It should be noted that DOC flux rates are also influenced by a number of other factors such as biological activity in the water column, dissolved oxygen in the water column, and the lability of the DOC to breakdown. The influence of these factors was not evaluated in this study.

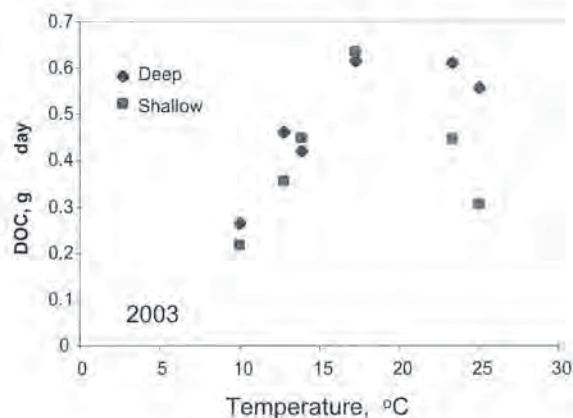


Figure 13. Relationship between ambient average air temperature and DOC flux rates in 2003 experiment. DOC flux rates estimated on a monthly basis.

For the year 2003, the DOC flux rates were estimated once every month and the relationship between rates and the ambient average air temperature is presented in Figure 13. Temperature data for June, July, and August used in this study was derived from the year 2002. Although there is some scatter in the relationships, there is a general trend on the influence of temperature on DOC flux rates.

In November 2003 tanks were filled to respective water depths and water column was monitored for TOC until June 2004. Again, only partial data are available to truly evaluate seasonal effects on TOC/DOC flux rates. Data in Figure 14 shows seasonal TOC flux rates during November 2003 to June 2004. Data collected in 2002 and 2003 showed that the ratio of DOC/TOC is in the range of 0.95 to 0.98. Thus, the TOC flux represents the DOC flux and comparisons can be made with previous years. Although TOC flux rates are substantially lower than previous years, similar seasonal effects were observed as compared to previous years. Highest flux rates were observed during the May-June months. Similar to other years, additional environmental data are needed to evaluate the role of temperature on flux rates.

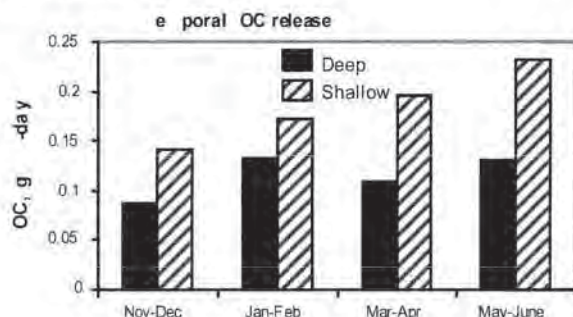


Figure 14. Seasonal influences on DOC flux from peat soil to overlying water column during 2003-2004. Deep = 2.9 m water depth; Shallow = 1.4 m water depth. Data points represent average values of four mesocosms for shallow and deep water depths.

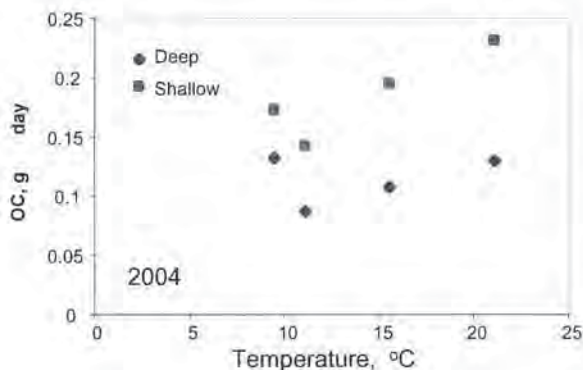


Figure 15. Relationship between TOC flux rates measured during 2004 (bimonthly) and average daily ambient temperature in the year 2002. Temperature data for 2004 are not available at the time of this report preparation.

Although there is considerable scatter in

these relationships, there is general trend between ambient daily air temperature and TOC flux rates. The flux rates did not double for every 10° C rise in temperature, suggesting that the TOC released into the water column is less labile than previous years.

A wide range of DOC flux rates (0.093 to 1.055 g/m² day) were observed in experiments conducted in 1999 and 2000 experiments. The average DOC flux rate in these experiments was 0.5 g/m² day. Experiments in 2002 involved repacking tanks with new soil. Average DOC flux measured during the year 2002 was 0.51 g/m² day. Average DOC flux during the subsequent experimental periods decreased to 0.4 and 0.15 g/m² day, respectively for 2003 and 2004. For comparison, we have calculated DOC fluxes for May-June period during each experimental period (Figure 16). Temperatures during this period are optimal for maximum biological activity and production of DOC.

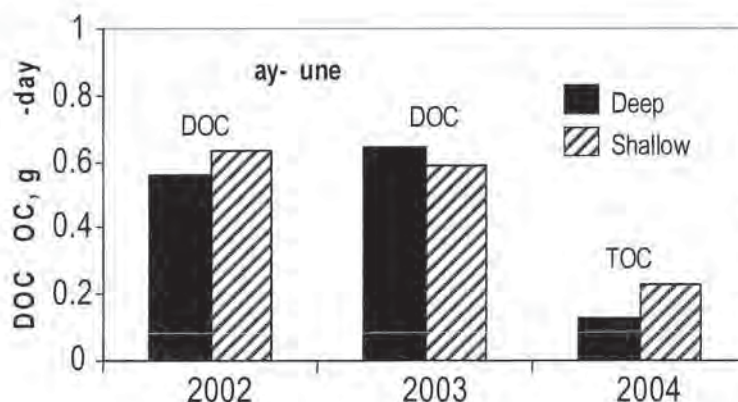
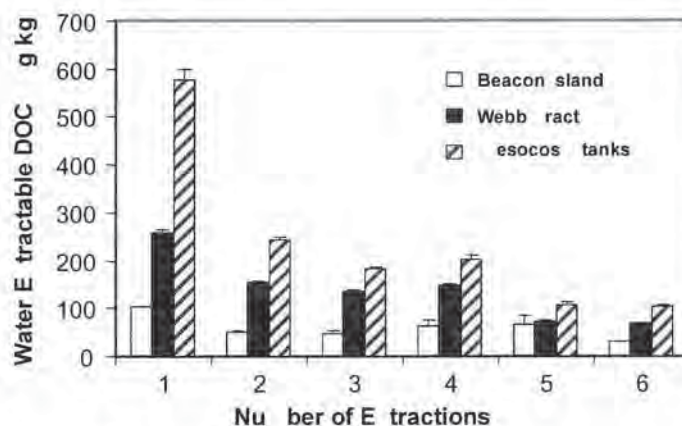


Figure 16. Dissolved organic carbon (DOC) and total organic carbon (TOC) release rates from flooded organic soils during May-June of each yearly experimental period. Data points represent average values of four mesocosms for shallow and deep water depths. In 2004, water samples were not analyzed for DOC

When compared 2002 DOC flux, May-June flux rates decreased by 18% in 2003 and by 72% in 2004 (Figure 16). In 2004 only TOC concentrations were measured. We assume that DOC represents approximately 95% of TOC, accordingly flux rates should be adjusted. Slow rates of DOC flux in 2004 suggests the initial 'tea bag' effect decreased and the system may be approaching steady state DOC flux from peat soil. With the limited data, it is difficult to estimate the time required to reach steady state DOC flux from soil to overlying water column.

Dissolve Organic Carbon Production

A simple laboratory study was conducted to determine the DOC leaching potential of three soils collected from the region. The study used two soils collected from Bacon Island and Webb Tract, and a third soil also from Bacon Island that was used in the mesocosm experimental tanks and flooded for a 3 year period. Soils were subjected for repeated sequential extractions for a total of 6 times during a 2-day period. Results are



presented in Figure 17.

Figure 17. Water extractable DOC from selected soils in the region.

Soils obtained from the field conditions had lower water contents representing drained conditions. The DOC release from two field soils was lower than the soil maintained under flooded conditions for a 3- year period. Under aerobic or drained conditions DOC breakdown is much faster and the decomposition is carried over all the way to CO₂ production. Under anaerobic conditions, decomposition of organic matter is slower and also incomplete, resulting in accumulation of labile DOC in soil. Similar results were observed in Florida's peatlands as shown in Figure 18. These results suggest that approximately 1.6 times more DOC is produced under flooded conditions than under drained conditions.

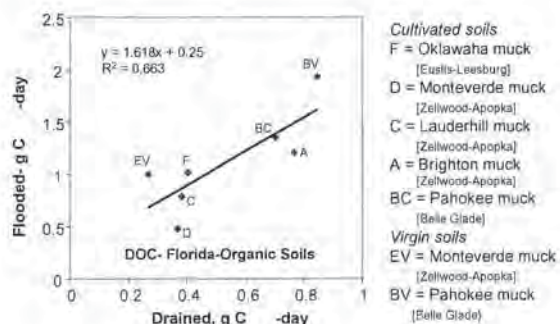


Figure 18. DOC release rates under flooded and drained conditions of several Florida's peatlands (Reddy, 1982).

Jones Tract Flooding and Water Quality Monitoring

On June 3, 2004, breach occurred on the levee of Middle River, resulting in flooding of Upper and Lower Jones Tracts (Figure 19). Approximately, 140,000 acre-feet of water



Figure 19. Map showing levee break in the Middle River west of Jones Tract.

flooded 12,165 acre farm land. Levee was restored and the pumpout operations began on July 12, 2004. At the time of flooding average depth of the water covering the rich Delta farmland was estimated at 3.5 m. To determine the effects of flooding, the Department of Water Resources (DWR) established a number of water quality monitoring stations as shown in Figure 20 and Table 2.



Figure 20. A map of Jones Tract showing water quality monitoring stations.

Table 2. Water quality sampling locations in Jones Tract.

SITES (see map at left for approximate locations)	N coordinate	W coordinate	Sampling depth
Lower Jones near the Intake (LJI)	N37°56.485'	W121°31.646'	1 meter below surface
LJ Mid island top of water column (LJMT)	N37°56.785'	W121°30.722'	1 meter below surface
LJ Mid island bottom water column (LJMB)	N37°56.785'	W121°30.722'	1/2 meter off bottom
LJ Discharge (LJD)			from sample port on discharge pipe
Upper Jones near Intake (UJI)	N37°56.223'	W121°31.592'	1 meter below surface
UJ Mid island top (UJMT)	N37°55.553'	W121°30.897'	1 meter below surface
UJ Mid island bottom (UJMB)	N37°55.553'	W121°30.897'	1/2 meter off bottom
UJ Discharge (UJD)			from sample port on discharge pipe
Middle River (MR)	N37°55.146'	W121°30.903'	sampled from shore with pole and can about 0.3 m below surface
Upper Jones Breach (UJB)	N37°55.252'	W121°30.975'	sampled from shore with pole and can about 0.3 m below surface
Lower Jones East Shore (LJES)	N37°57.170'	W121°27.166'	sampled from shore with pole and can about 0.3 m below surface
LJES Duplicate (LJESD)	N37°57.170'	W121°27.166'	sampled from shore with pole and can about 0.3 m below surface

Soils in the Jones Tract are Histosols with peat depths of up to 3 m. Although flooding of 12,000 acre farmland is an environmental disaster, it does provide an opportunity to

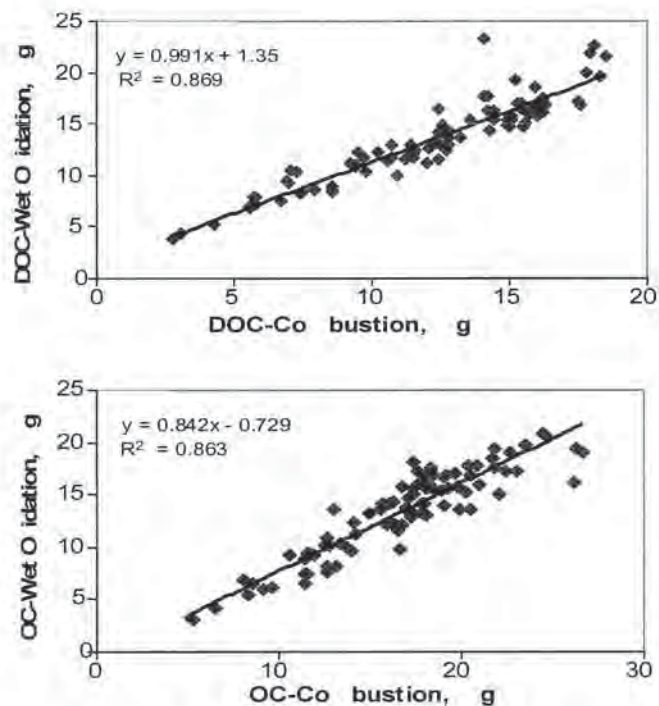


Figure 21. Relationship between TOC/DOC determined by wet oxidation and combustion methods.

determine the effect of flooding on TOC and DOC release potential of peat soils. In this report we present a preliminary analysis of water column DOC and TOC data and determine the flux rates from soil to overlying water column.

Water samples obtained were analyzed for DOC and TOC using both wet oxidation method and total combustion method. A comparison of both methods is presented in Figure 21. Both methods showed similar recoveries with respect to DOC analysis. However, TOC analysis by wet oxidation method accounted for 84% of the TOC determined by combustion method. These results suggest that wet oxidation provides incomplete oxidation of organic carbon resulting in lower recoveries. For all other data analysis, we will use DOC and TOC determined by combustion method.

Data on relationship between TOC and DOC of water samples are shown in Figure 22. Approximately 84% of the TOC was present as DOC and the remaining as POC. The source of POC in was probably due to resuspension of fine soil particles from the underlying peat soils and plankton in the water column.

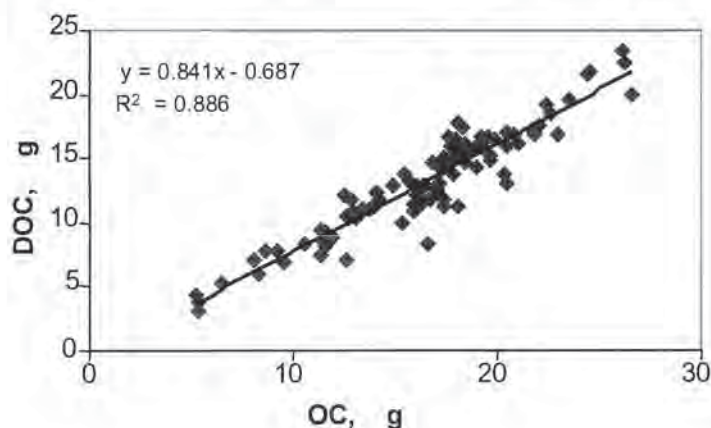


Figure 22. Relationship between TOC and DOC of water samples collected from flooded Jones Tract.

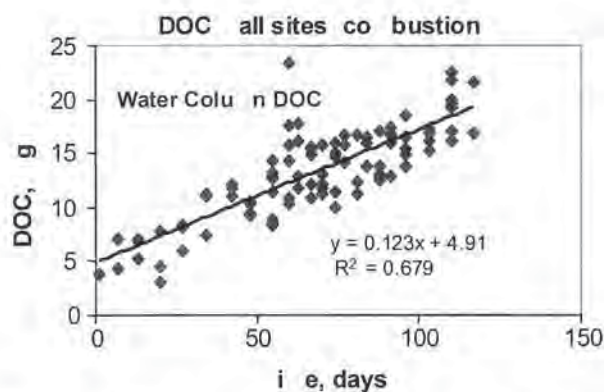


Figure 23. Influence of flooding on dissolved organic carbon concentration of the water column.

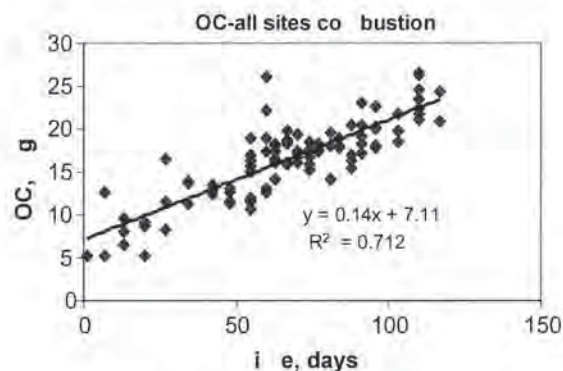


Figure 24. Influence of flooding on TOC release (samples from all sites) from peat soil to the overlying water column.

For all sampling sites, DOC concentrations in the water column increased steadily from 5 mg/L to approximately 20 mg/L, in about four months (Figure 23), while TOC concentrations increased from 6 mg/L to approximately 25 mg/L (Figure 24). Similar trends in DOC and TOC increase were observed for both Lower and Upper Jones Tracts, suggesting very little difference in characteristics soil organic matter in both regions (Figure 25 and 26).

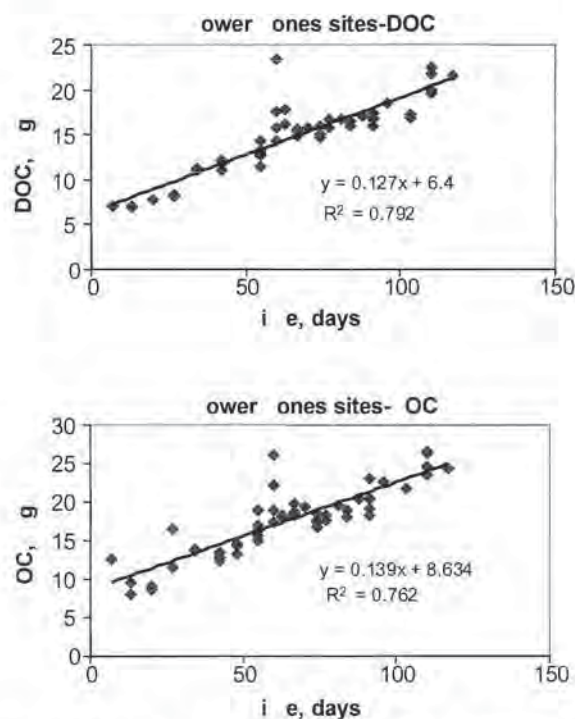


Figure 25. Influence of flooding on DOC and TOC release in Lower Jones Tract

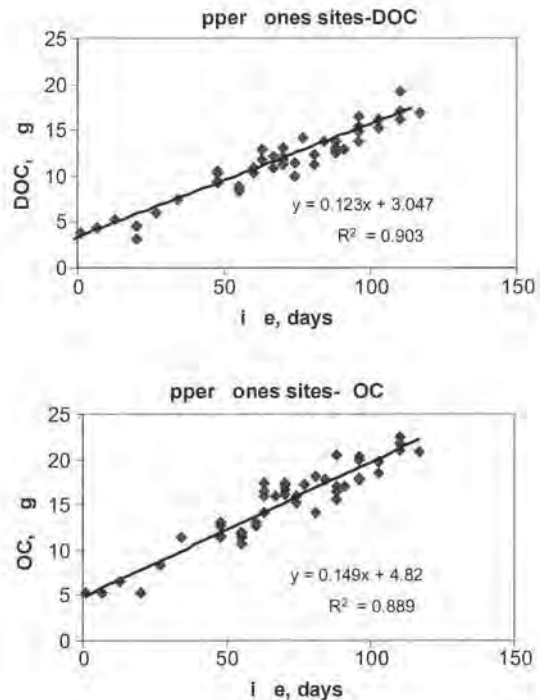


Figure 26. Influence of flooding on DOC and TOC concentrations of water in Upper Jones Tract

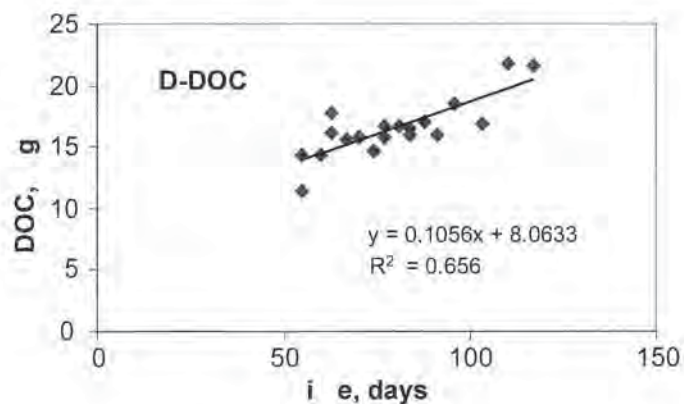


Figure 27. Dissolved organic carbon concentration of the water samples collected from the discharge point in Lower Jones Tract.

Water samples from two discharge stations (LJD and UJD) were obtained 55 days (July 29, 2004) after flooding occurred. At this point DOC and TOC concentrations increased from 5 mg/L to approximately 15 mg/L. Slightly lower DOC and TOC levels were observed in water samples collected from two discharge sites in Lower a (LJD) (Figures

27 and 28) and Upper (UJD) Jones Tract (Figure 29), as compared to interior sites. This may be due to possible dilution during pumping events.

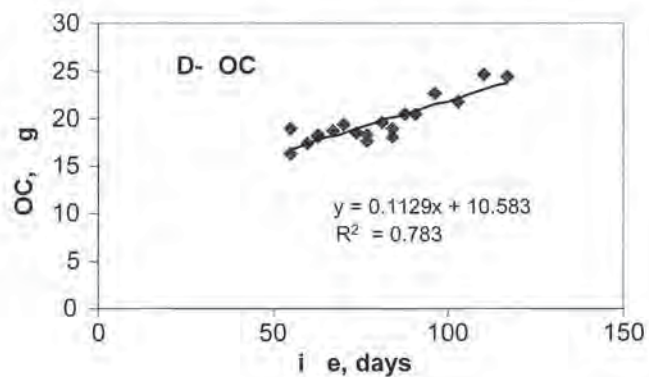


Figure 28. Total organic carbon concentration of the water samples collected from the discharge point in Lower Jones Tract.

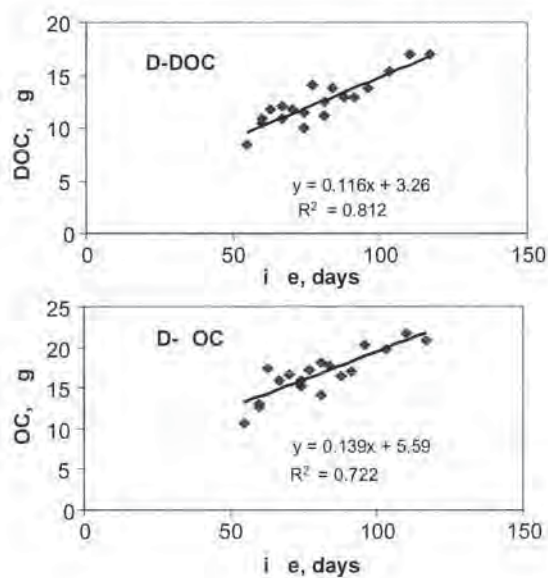


Figure 29. Dissolved and total organic carbon concentrations of the water samples collected from the discharge point in Upper Jones Tract.

At all sampling sites, flooding increased DOC and TOC concentrations of the water column by approximately five times in four months. Mesocosm studies have shown that

when drained soils are flooded, initially substantial amounts of DOC and TOC released. Average estimated water depth in the Jones Tract during the sampling period was estimated to be 2.61 m. Slopes of regression equations presented in Figures 22-29 were multiplied to estimate flux rates expressed as $\text{g C/m}^2 \text{ day}$. Results are presented Table 3.

Table 3. Dissolved organic carbon (DOC) and total organic carbon (TOC) release rates from flooded peat soils in the Jones Tract.

Experimental conditions	DOC Release Rate [$\text{g C/m}^2 \text{ day}$]	TOC Release Rate [$\text{g C/m}^2 \text{ day}$]
<i>Jones Tracts WQ monitoring</i>		
<i>June 2004-September 2004</i>		
Average water depth = 2.61 m		
All sites	0.321	0.365
Lower Jones sites	0.331	0.363
Upper Jones sites	0.321	0.389
LJD	0.276	0.295
UJD	0.302	0.362

Both DOC and TOC flux rates presented in Table 3 are approximately in the same range as those observed in mesocosm experiments (Table 1). Accurate water depth estimates are key in determining the reliability of estimated DOC and TOC flux rates. The flux rates reported in Table 3 assume a constant water depth and DOC and TOC

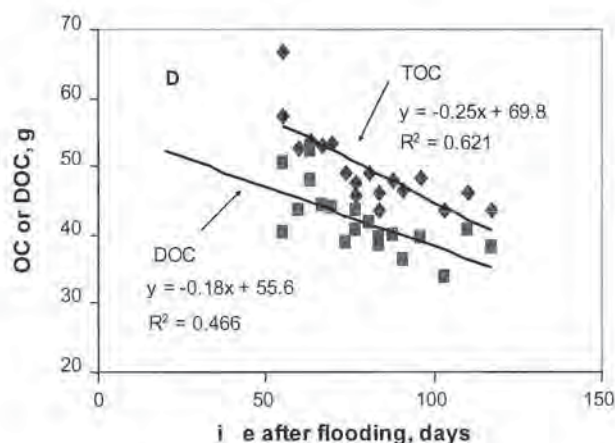


Figure 30. Mass TOC and DOC release as estimated based on calculated water depths in the Lower Jones Tract.

concentration increase occurred at this depth. Water depth was estimated based on acre-feet present at the time flooding and normalized to area of the Jones Tract. It is estimated

that at the time pumping started (July 12, 2004, day 38 after flooding), there was approximately 140,000 acre-feet of water present in an area of 12,165 acres. This resulted in approximate water depth of 3.6 m. As water was pumped out of the Jones Tract, water depth steadily decreased. At the last sampling period (September 28, 2004, day 117 after flooding), the amount of water present in Jones Tract was 71,000 acre-feet, which resulted in a calculated water depth of 1.8 m. Based on estimated water depths, we have calculated mass of DOC and TOC released into the water column. One example of these results for LJD site is presented in Figure 30.

At LJD site, mass DOC and TOC release, 55 days after flooding (July 28, 2004) was highest and decreased during next two months of pumping events, even though concentrations increased during that time (Figure 31). It was expected that mass TOC and DOC will increase with time, as observed in the mesocosm experiments. Increase in TOC and DOC concentrations in the water column were not high enough to compensate for the decrease in water depth during pumping events.

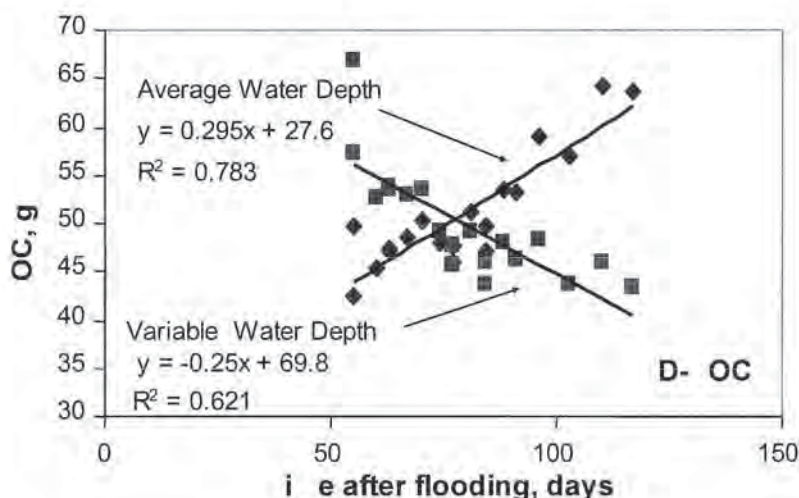


Figure 31. Mass DOC and TOC release from Day 55 to Day 117 after flooding of Jones Tract. Water depth this period was estimated to be 3.51 m.

Similar trends were observed for all sampling sites (Figure 32). An inverse relationship was observed between mass TOC release estimated using average water depth and variable water depth. Estimates based on variable water depth were probably more representative of dynamic changes occurring under field conditions. This raises a key concern on the reliability of estimated water depths for the whole area. Alternatively, the data on DOC and TOC concentrations were not adequate to truly represent the dynamic changes in the water column. Thus caution should be exercised on the use of Jones Tract DOC and TOC loading rates presented in Table 3.

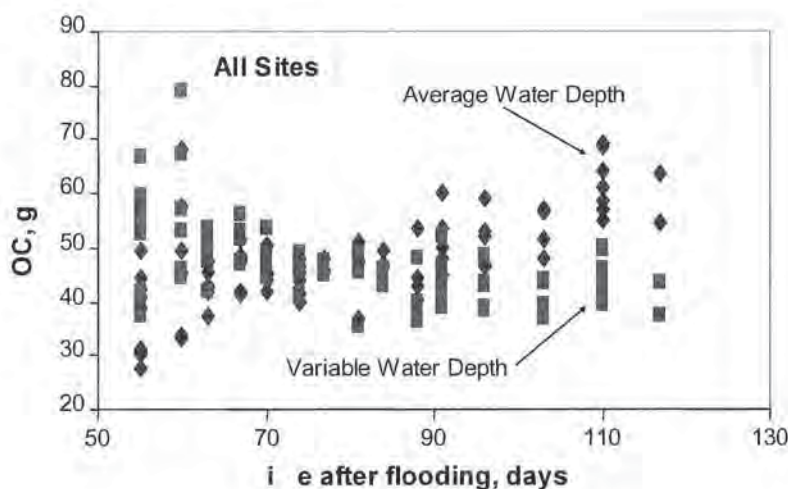


Figure 32. Mass DOC and TOC release from flooded Jones Tract (all sampling sites), as estimated (1) using average water depth (2.61 m), and (2) using variable water depth during the pumping period

Jones Tract was flooded on June 3, 2004 and water pumping was started July 12, 2004 (Day 38 after flooding). Estimated water depth during the initial flooding period (until July 28) was approximately 3.51 m. For this initial period of flooding, mass DOC and TOC release were calculated using 3.51 m water depth and data for all site are presented in Figure 33 and Table 4. During this period, mass DOC and TOC increased by 2 to 3 times, indicating initial flushing of labile organic carbon from soil to overlying water column. Similar flux rates were observed for both DOC and TOC and these values are approximately in the same range as those observed in 2002 and 2003 mesocosm experiments.

Table 4. Dissolved organic carbon (DOC) and total organic carbon (TOC) release rates from flooded peat soils in the Jones Tract during the first 50 days after flooding

Experimental conditions	DOC Release Rate [g C/m ² day]	TOC Release Rate [g C/m ² day]
<i>Jones Tracts WQ monitoring</i>		
<i>June 3, 2004-July 28, 2004</i>		
Water depth = 3.51 m		
All sites	0.482	0.482

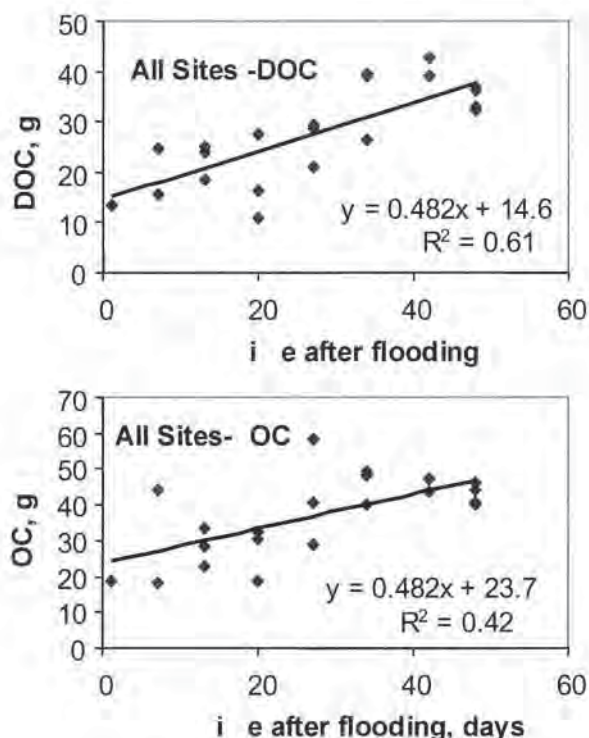


Figure 33 Mass DOC and TOC release during the first 48 days of flooding of the Jones Tract. Water depth for this period was estimated to be at 3.51 m.

General Discussion on Behavior of Organic Soils

Histosols (also known as peatlands or organic soils) are characterized with high organic matter (>12% total carbon) in the upper one meter of the profile. Soil formation is due to accumulation of partially decomposed organic matter, where peat decomposition processes can not keep up with primary productivity. Extensive areas of peatlands are found in northern parts of the U.S. (examples in Alaska and Minnesota) and in Canada. In southern large areas of the U.S., peatlands are found in the pocosins and Carolina bays of the southeast and the Everglades in south Florida. Surface horizons are usually well decomposed underlain by fibrous undecomposed peat. This differentiation is based on drained organic soils. Organic soils have high water-holding capacity and poor drainage. Upon flooding, these soils are rapidly reduced assuming intense anaerobic soil conditions, with Eh dropping to <-200 mV within a few days after flooding. Under a natural state, as mentioned earlier, peat forms as a result of plant litter accumulation from hydrophytic vegetation. Several million hectares of peatlands in North America, Europe, USSR and southeast Asia have been drained for farming. Organic soils are naturally productive and contain large amounts of organic carbon and associated nutrients.

When the flooded organic soils in the Delta were drained for agricultural purposes, the process of organic matter accumulation was completely reversed. Under drained conditions, peat soils can oxidize at a rate of about 3 cm per year. Converting these drained soils into water storage reservoirs will result in anaerobic conditions in soils, thus decreasing the overall decomposition process. Flooding results in solubilization of organic matter and accumulation of partially decomposed organic compounds, thus contributing to dissolved organic matter.

Conclusions

The experimental mesocosm study conducted during 2002-2004 showed rapid release of DOC during the first year that decreased significantly during the 2nd and 3rd years (Table 5). The DOC flux rates shown in Table 5 represent average values for the whole year. Maximum flux rates represents summer and warmer conditions influencing the organic matter decomposition rate, while the minimum flux rates for any given year represents winter or more cooler conditions. Results show a positive relationship between DOC flux rates and temperature, with flux rates approximately increased by 1.5 to 2 times for every 10 C rise in temperature. This is typical of many biological systems and similar trends are reported for other systems (Reddy, 1982).

Table 5. Dissolved organic carbon (DOC) and total organic carbon (TOC) release rates from flooded peat soils in mesocosms during 3 year study.

Year	Average g DOC/m ² day	SD	Max g DOC/m ² day	Min g DOC/m ² day
2002	0.612	0.229	1.098	0.403
2003	0.380	0.160	0.642	0.216
2004*	0.146	0.05	0.231	0.087

*TOC flux rates

Flooding well drained peat soils results in a flush of DOC release from soil to the overlying water column. Under drained conditions, microbial biomass contains both aerobic bacteria and fungi. Upon flooding and creating anaerobic soil conditions much of these active microbial populations die and the metabolic activities switch over to facultative and anaerobic bacteria. As a result, microbial groups that depend on oxygen as their terminal electron acceptor during respiration, now depend on alternate electron acceptors. Organic matter decomposition under these conditions is typically slower and results in solubilization of organic matter and accumulation of dissolved organic compounds. Thus, flux of DOC from soil to overlying water column is rapid during the first few months of flooding and decreases with time. Depending on environmental conditions and hydrology, initial flush of DOC may sustain a few months to 1-2 years, as observed in the mesocosm study (Table 5). Once the system reaches steady state, the flux from soil to overlying water column will depend on production of DOC within the soil profile. In addition, deposition of macrophyte detrital matter and dead algal cells on the soil surface may prevent the flux of DOC from soil. However, at that time, DOC

generation in the water column will depend on the decomposition of detrital matter. The DOC concentration of water column is inversely related to the dissolved oxygen concentration of the water column.

Results presented in this report suggest that the initial “tea bag” effect sustains about 2 years. In relation to the first year DOC flux rates, the rates decreased approximately by about 40% after 2 years of flooding and by about 70% after 3 years of flooding. Average DOC flux from the mesocosm experiments during the first year was $0.612 \text{ g C/m}^2 \text{ day}$, while the DOC release rates from the Jones Tract flooding during first 2 months of flooding was $0.48 \text{ g C/m}^2 \text{ day}$.

The DOC flux rates obtained from mesocosms provide reasonable estimates, albeit these rates may represent the upper end of the scale. The mesocosm water column is operated as a static system and lacks typical hydrodynamic events observed under field conditions. Under field conditions it is likely that the DOC turnover rates will be higher than those obtained in the mesocosm experiments.

Additional Data Needs

The following additional information is needed to determine the long-term steady state flux of DOC and TOC release potential from peat soils to the overlying water column.

- Spatial variability of soil properties at the proposed reservoir sites. Basic soil properties such as organic matter content (loss on ignition), extractable carbon and nutrients and drained and flooded conditions.
- Characterization of peat soil, with respect to organic matter fractions. At the minimum determine the labile portions of carbon that can be potentially broken down into DOC.
- Chemical characterization peat soil. Cellulose-lignin ratios. Use NMR techniques to determine organic matter fractions.
- Determine the bulk density of soil column and estimate the total carbon storage in soil.
- Characterize dissolved organic matter using NMR techniques.
- Determine the biodegradability of the TOC and DOC in the water column.
- Soil oxygen demand (SOD) and biochemical oxygen demand (BOD) can provide some simple indication of the biodegradability of soil and water carbon pools.
- Maximum DOC leaching potential of peat soils and how soil properties affect DOC release.
- Determine the influence of prior soil conditions and agricultural management practices on labile pools of organic matter.
- Continue to monitor mesocosm tanks for DOC and TOC with hydraulic retention times typical of proposed reservoirs. At the minimum, samples should be analyzed for TOC. Frequency of samples should be increase to once a week, at least for a period of one year to determine the temporal effects on TOC flux.

- Physico-chemical environment of the water column should be monitored. At the minimum dissolved oxygen and temperature should be monitored on a continuous basis.
- Determine the role of abiotic breakdown of DOC and TOC.
- Biotic breakdown of DOC and TOC, including enzymatic hydrolysis and microbial breakdown.
- Redox regulation soil organic breakdown and DOC generation. This should include hydrology and water table fluctuations, alternate flooding and draining, role of alternate metabolic pathways including sulfate reduction and methanogenesis.
- Relative DOC flux from plankton/macrophytes and soil needs to be determined.
- Although controlled experiments provide useful information, it is important to conduct field studies under more realistic conditions. Jones Tract data provides some of that information. Techniques are available to measure DOC fluxes under field conditions. Consider constructing a pilot scale reservoir (approximately 10 acres) and monitor water quality parameters. This will give more reliable information that can relate to full scale reservoirs.

References

- Chrost, R. J. 1991. Environmental control of the synthesis and activity of aquatic microbial ecotoenzymes. In *Microbial Enzymes in Aquatic Environments*. R. J. Chrost (ed.) Springer-Verlag, New York. Pp29-83.
- De Haan, H. 1993. Solar-UV-light penetration and photodegradation of humic substances in peaty lake water. *Limnol Oceanogr.*38: 1072-1076
- Freeman, C., N. Fenner, N. J. Ostle, H. Kang, D. J. Dowrick, B. Reynolds, M. A. Lock, D. Sleep, S. Hughes, and J. Hudson. 2004a. Dissolved organic carbon export from peatlands under elevated carbon dioxide levels. *Nature*. 430:195-198.
- Freeman, C., N. J. Ostle, N. Fenner, H. Kang. 2004. A regulatory role for phenol oxidase during decomposition in peatlands. *Soil Biol. Biochem.* 36: 1663-1667.
- Moran, M. A. and R. G. Zepp. 1997. Role of photoreactions in the formation of biologically labile compounds from dissolved organic matter. *Limnol. And Oceanogr.* 42: 1307-1316.
- Moran, M. A., and J. S. Covert. 2003. Photochemically mediated linkages between dissolved organic matter and bacterioplankton. In *Aquatic ecosystems: Interactivity of dissolved organic matter* (E. Stuart, G. Findlay, and L. Sinsabaugh editors). Academic Press, New York. Pp 512
- Reddy, K. R. 1982. Mineralization of nitrogen in organic soils. *Soil Sci. Soc. Am.* 46:561-566.

- Reddy, K. R. and E. M. D'Angelo. 1994. Soil processes regulating water quality in wetlands. In. Global Wetlands - Old World and New (W. Mitsch ed). p 309-324. Elsevier Pub. New York.
- Stevenson, F.J., 1994, Humus Chemistry: Genesis, Composition, Reactions, New York, John Wiley and Sons, 496 p.
- Stuart, E, G. Findlay, and L. Sinsabaugh. 2003. Aquatic Ecosystems: Interactivity of Dissolved Organic Matter. Academic Press, New York. Pp 512.
- Wetzel, R. G., P. G. Hatcher and T. S. Bianchi. 1995. Natural photolysis by ultraviolet irradiance of recalcitrant dissolved organic matter to simple substrates for rapid bacterial metabolism. Limnol. Oceanogr. 40: 1369-1380.
- Wright, A.L. and K.R. Reddy. 2001. Phosphorus Loading Effects on Extracellular Enzyme Activity in Everglades Wetland Soil. Soil Science Society of America Journal 65:588-595.

Potential Impacts of Large-Scale Delta Levee Failure on BDCP Restoration and Intake Investments

RMA Model Analysis

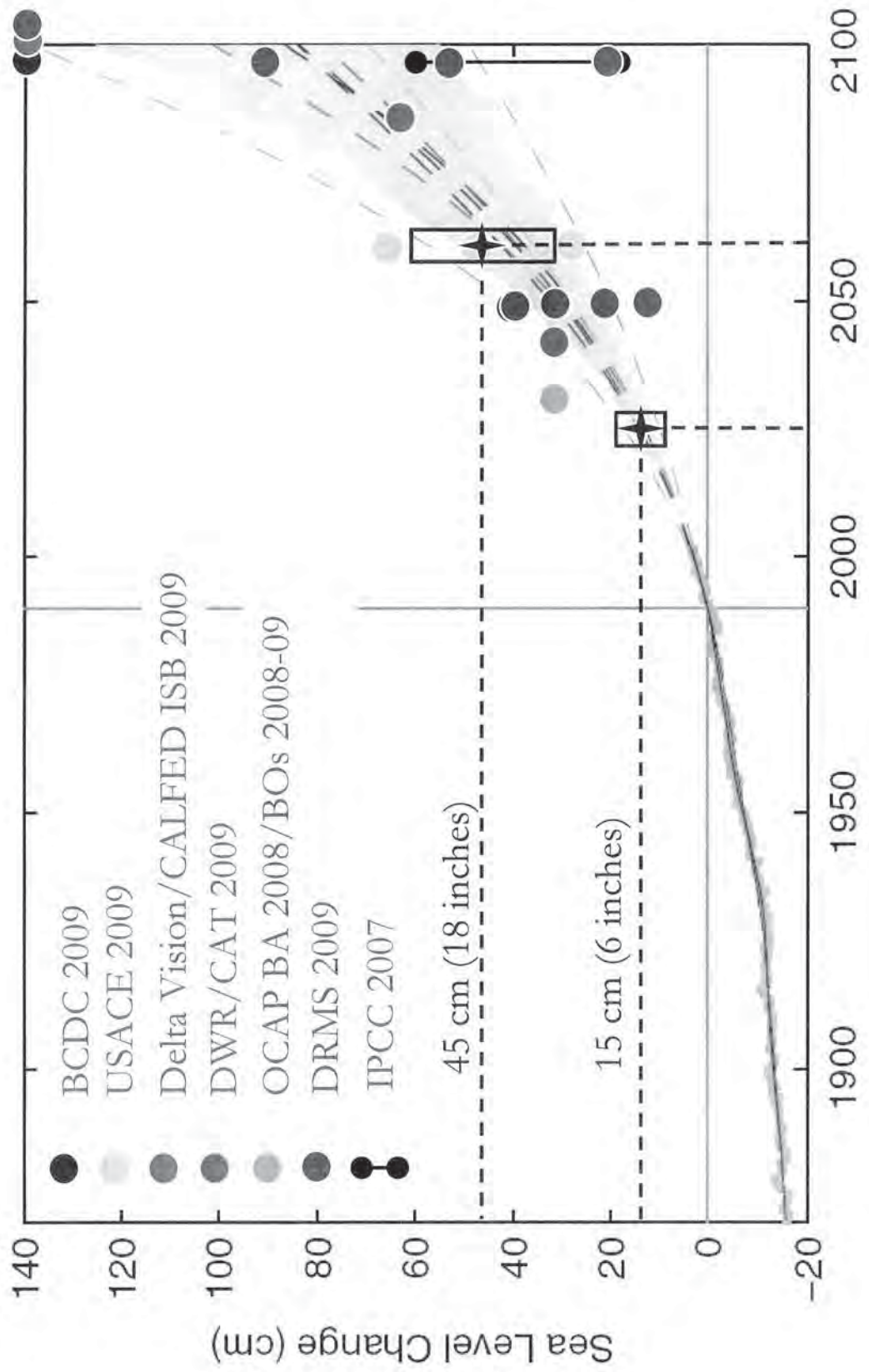
Modeling Summary

Two sets of analyses were performed:

- Breach event – short-term (4-month) simulation with simultaneous breaching of all affected islands to determine peak salinity intrusion
- Long-term (two-year) simulation starting with islands already breached to evaluate long term effects on salinity and tidal range

Simulations performed with no sea level rise and with extreme sea level rise of 140 cm (note that ROA geometry was originally developed for up to 45 cm SLR and other model geometry was not extended to represent the shoreline change with SLR)

Navigating Sea Level Rise Uncertainty



Short-Term Breach Event

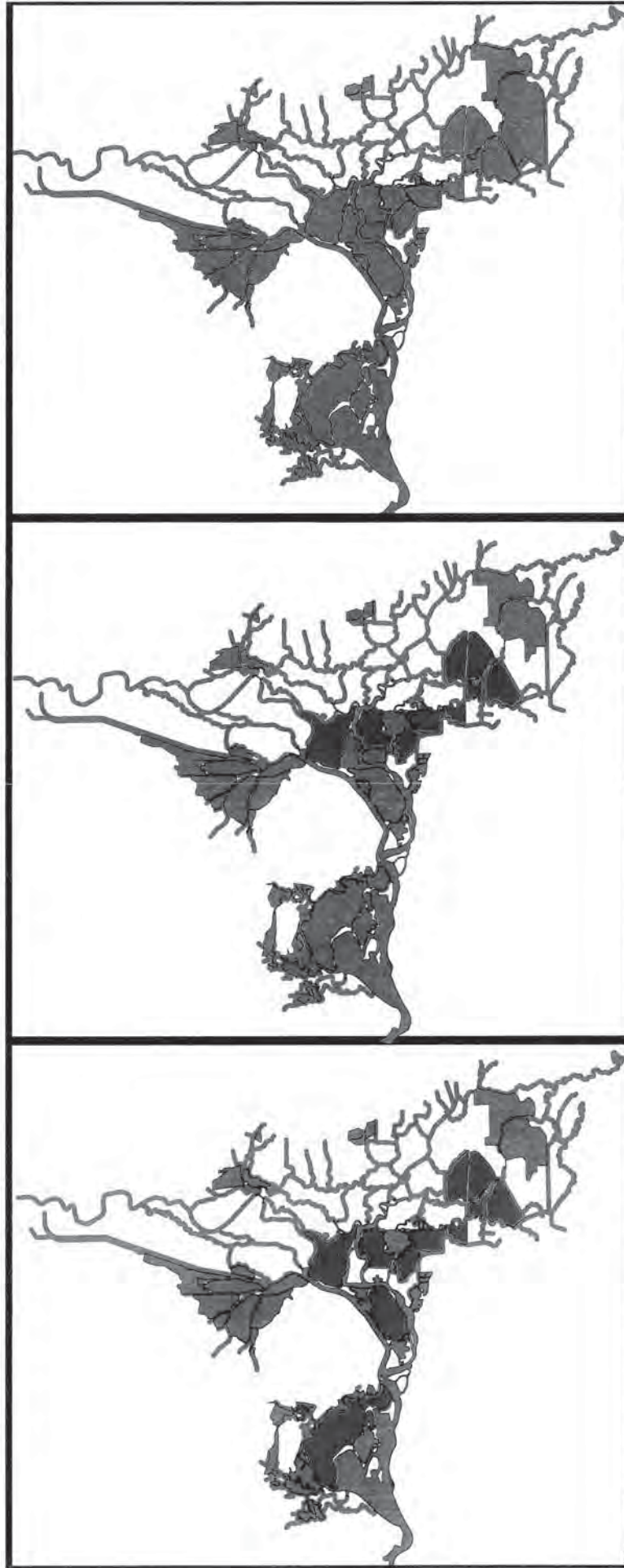
Model Assumptions

- Simulations were run September – December 1990
- Initial conditions taken from long-term “no breach” simulations
- Breach event occurs on October 1, 1990 at 1:00 AM
- Two failure scenarios are considered, all include LLT restoration:
 - 3 Island failure scenario (plus Grizzly Island failures)
 - Hayward failure scenario (plus Grizzly Island failures)
- Two tidal boundaries are considered
 - Historical Golden Gate tide (no sea level rise)
 - Historical Golden Gate tide plus 140 cm sea level rise
- South Delta Exports turned off for one week following breach event, then ramped back up for one week

Base Scenario – LLT
Restoration Only

Hayward Scenario

3 Island Scenario

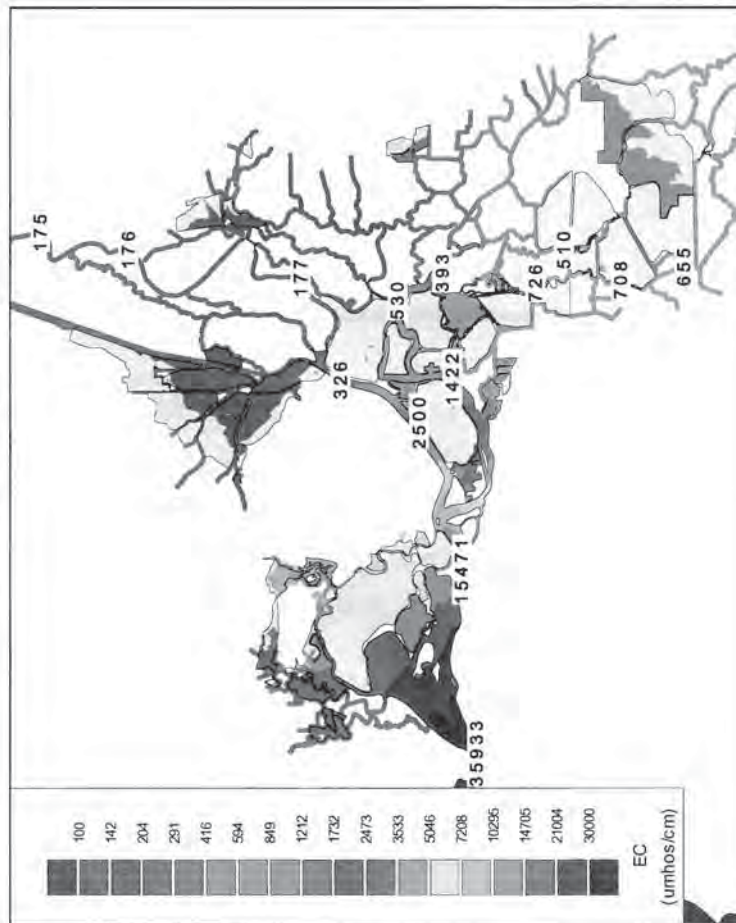


Red areas are not flooded

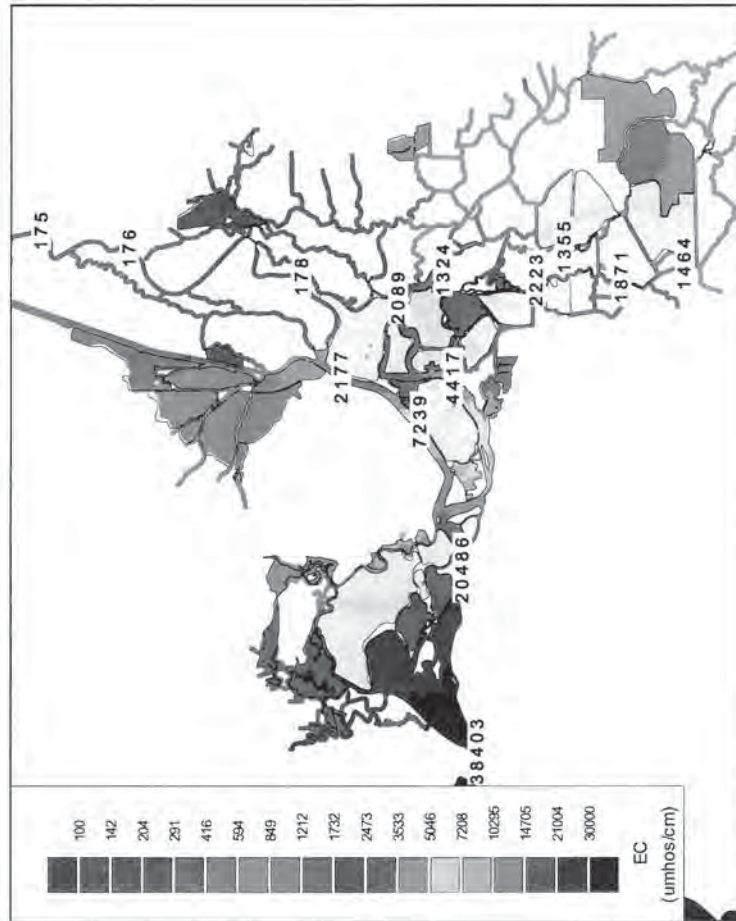
Sep 30, 1990 @ 24:00

Pre-Breach Event

No Sea Level Rise



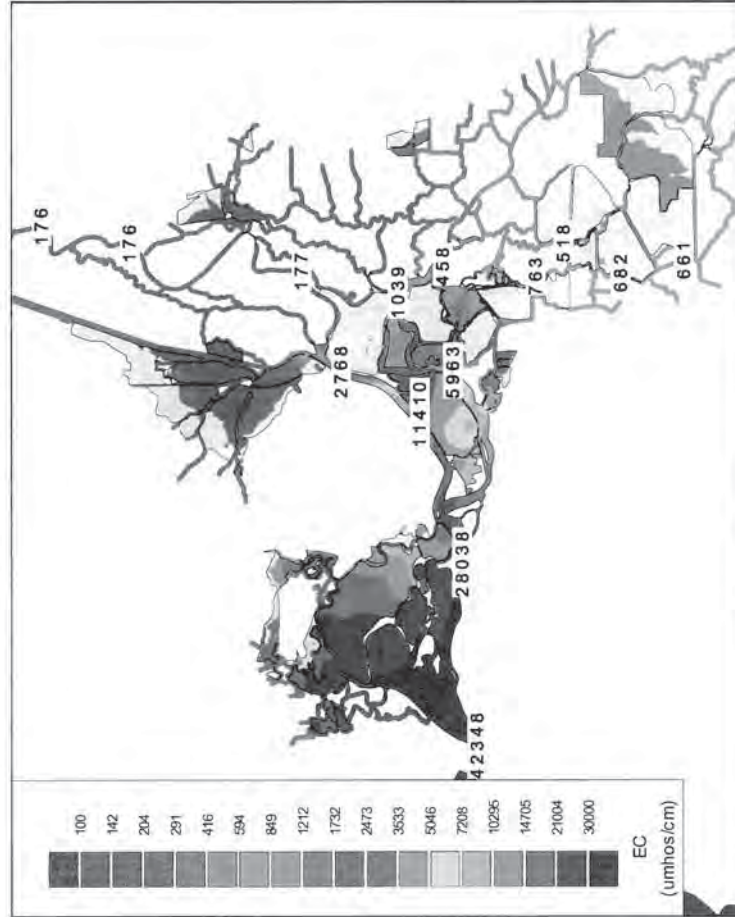
140 cm Sea Level Rise



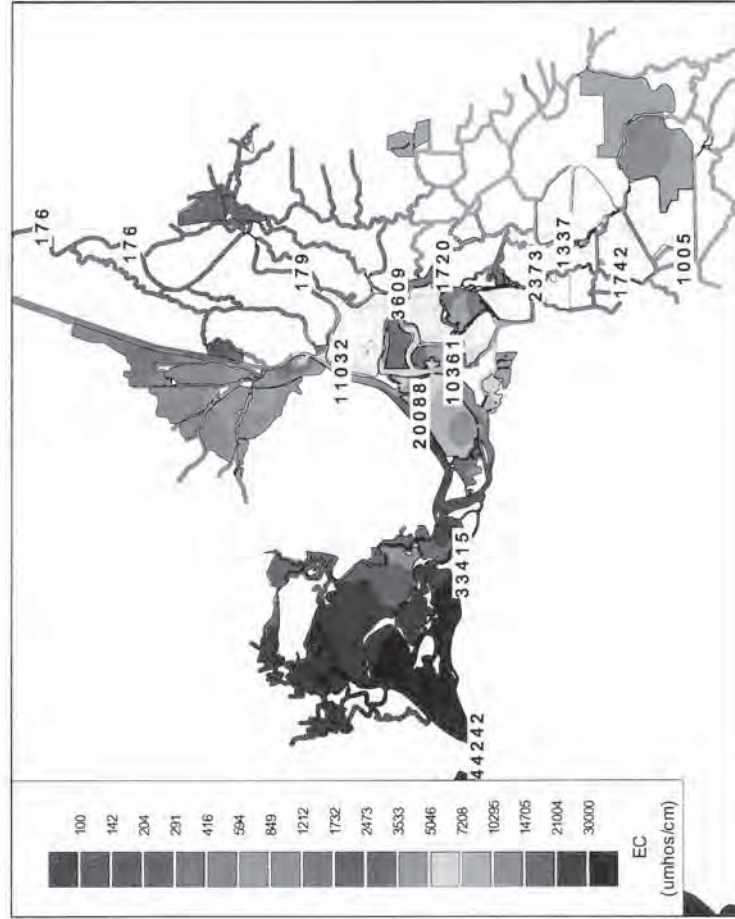
Oct 7, 1990 @ 19:00

Three Island Event

No Sea Level Rise



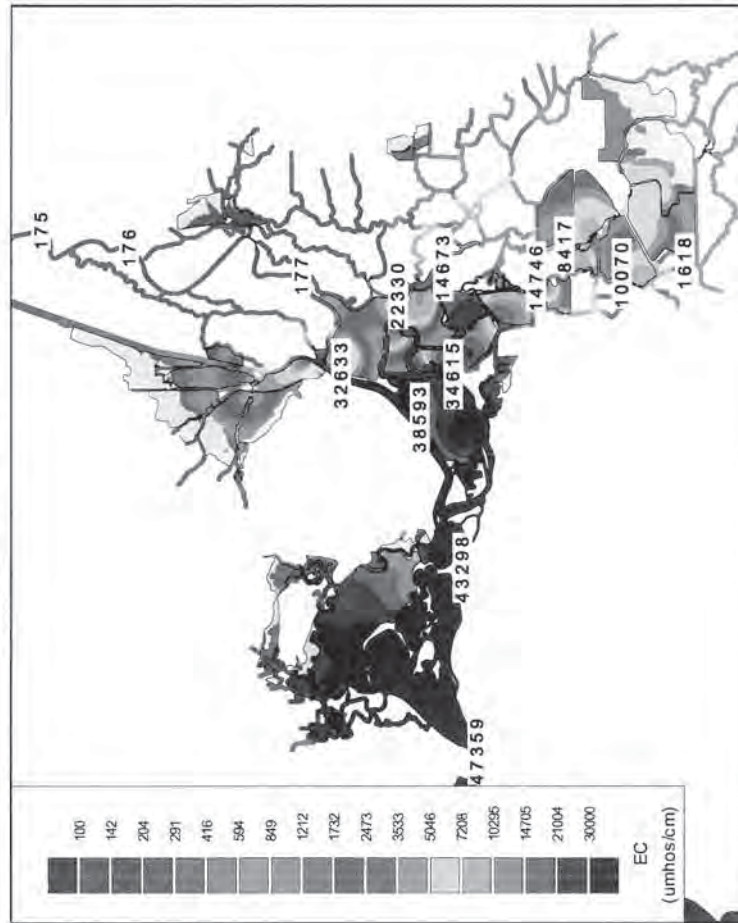
140 cm Sea Level Rise



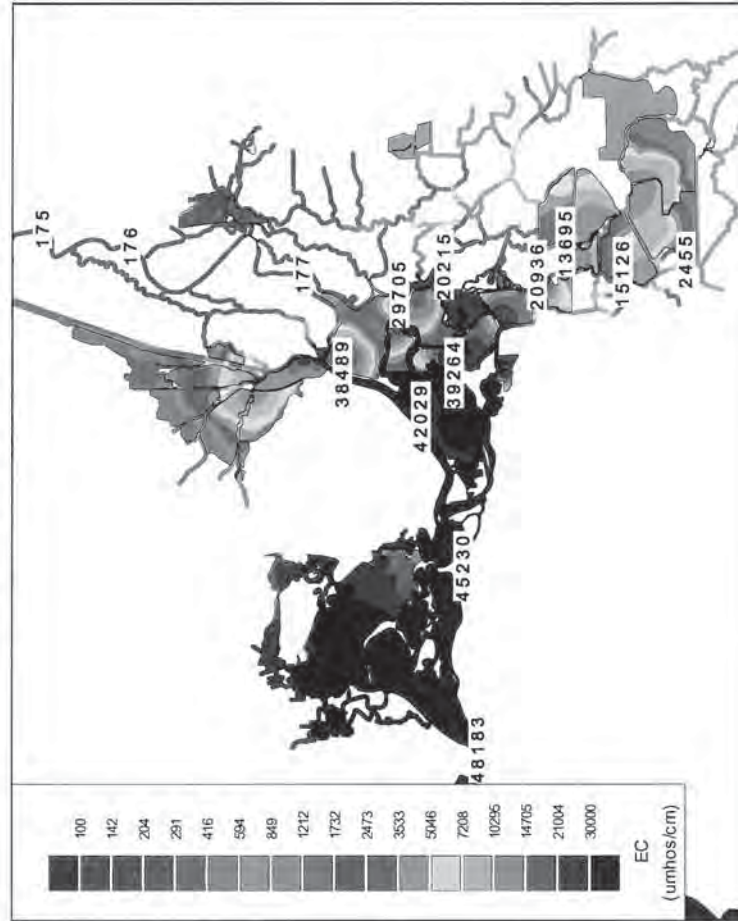
Oct 7, 1990 @ 19:00

Hayward Event

No Sea Level Rise

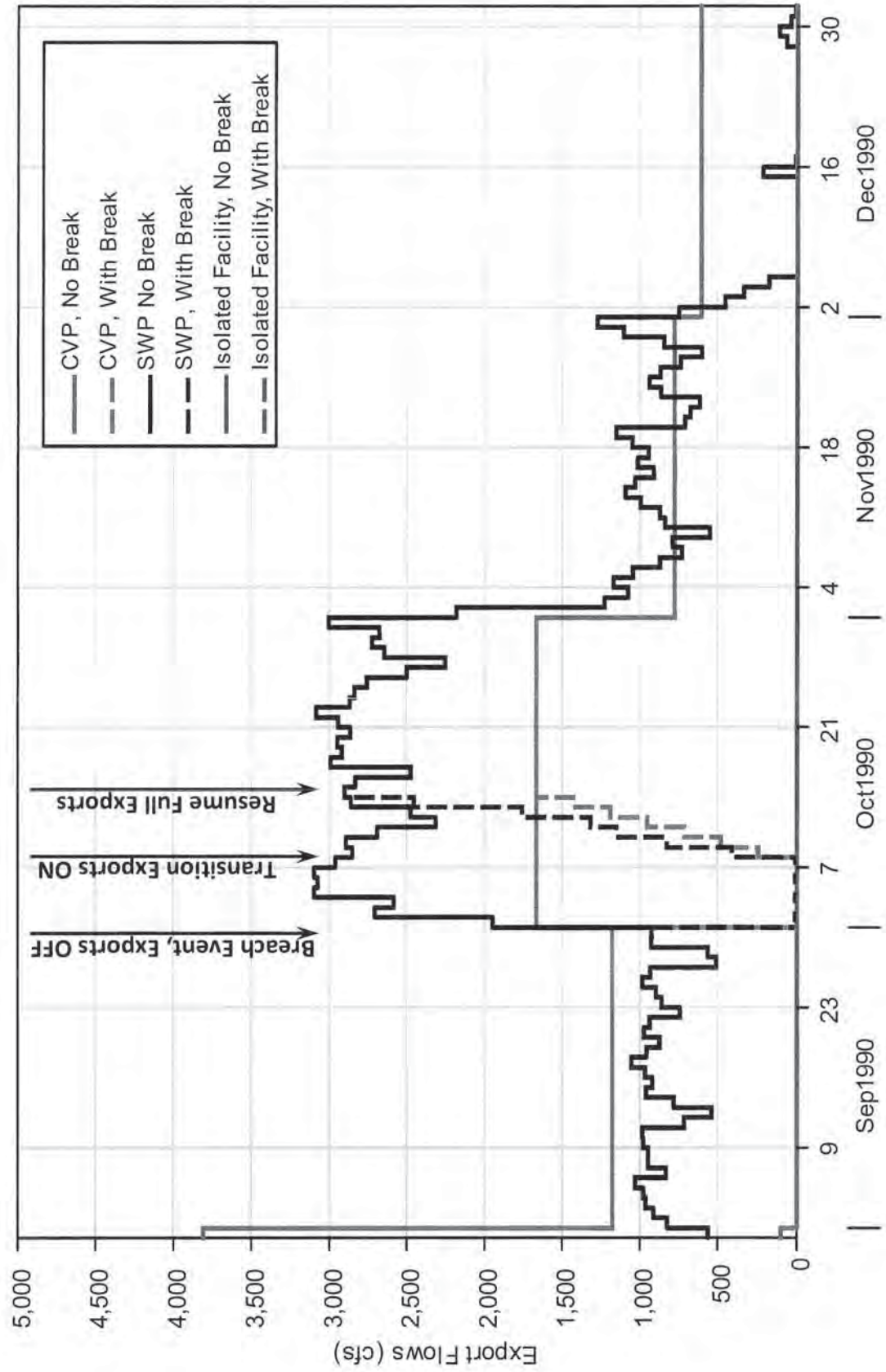


140 cm Sea Level Rise



Export Flows, Sep 1 to Dec 31, 1990

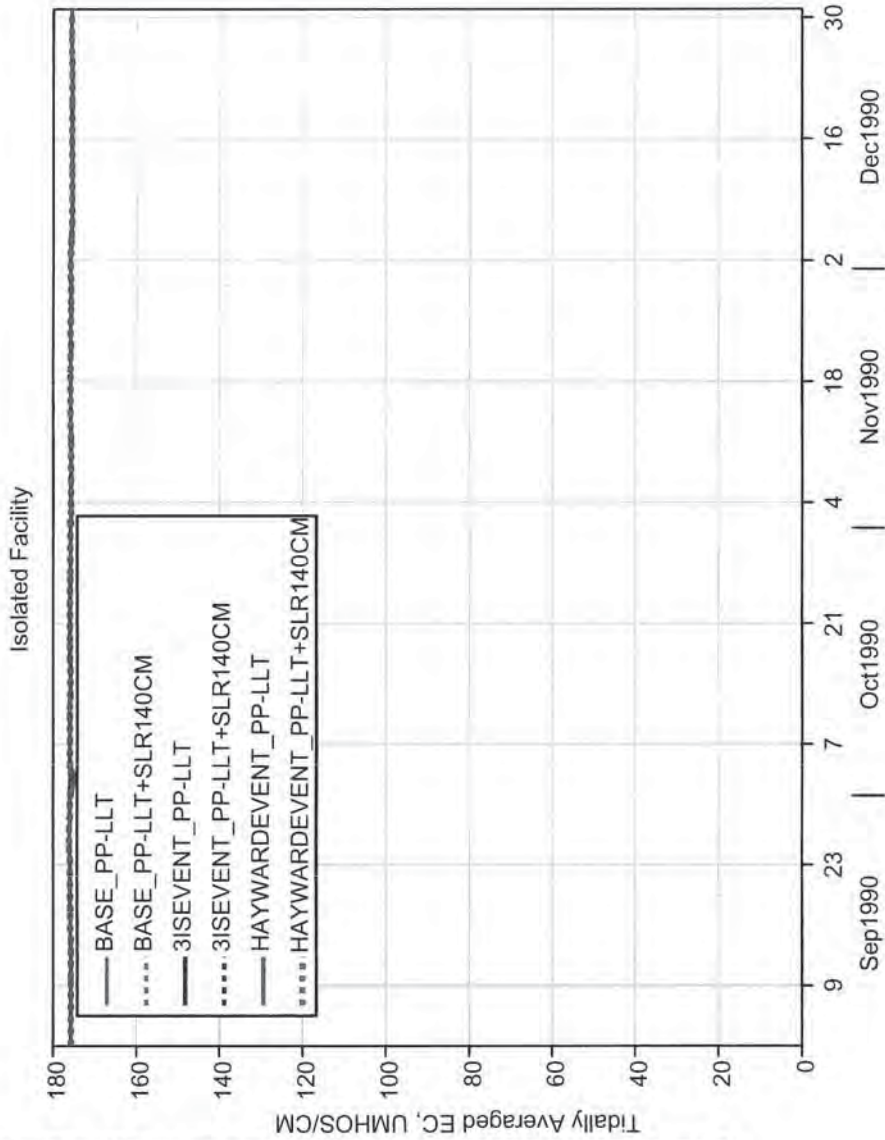
Levee Breach Event vs. No Breach



Tidally Averaged EC, Sep 1 to Dec 31, 1990

Base, 3 Is Event, Hayward Event

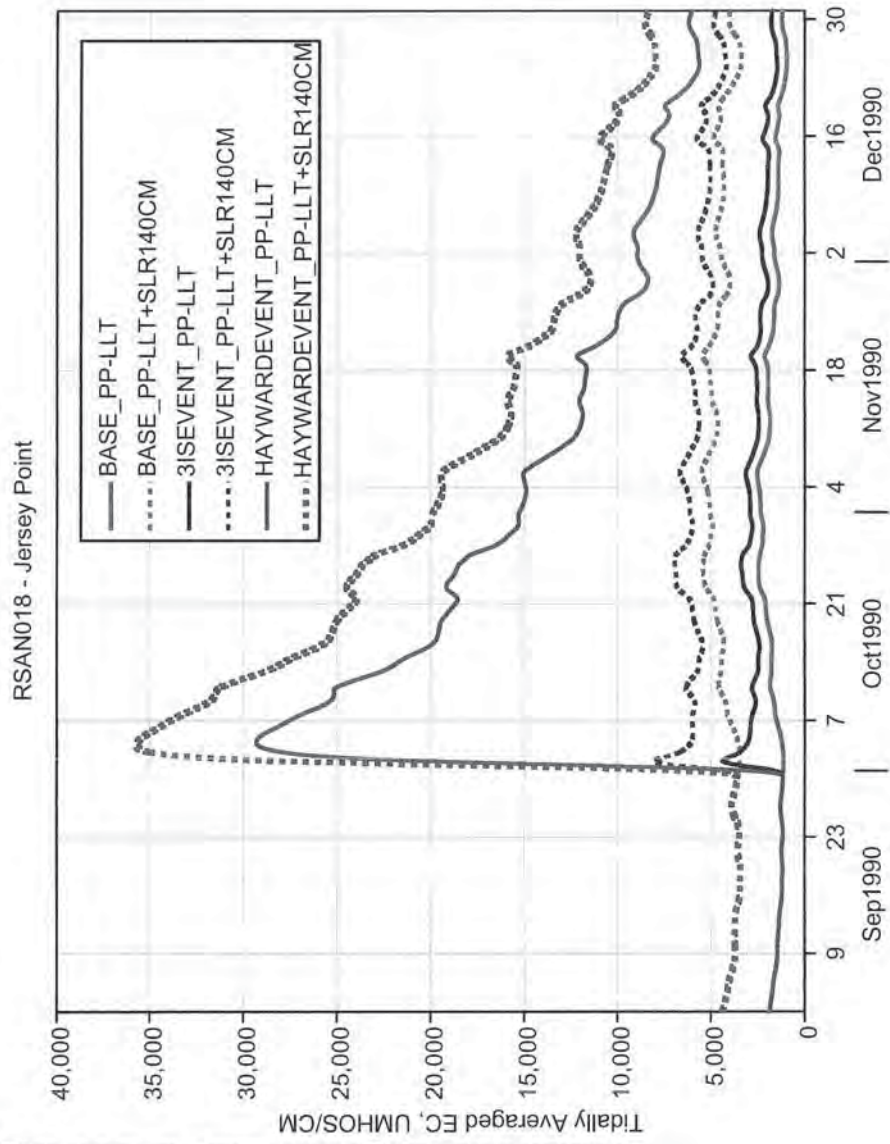
Isolated Facility



Tidally Averaged EC, Sep 1 to Dec 31, 1990

Base, 3 Is Event, Hayward Event

RSAN018 – Jersey Point

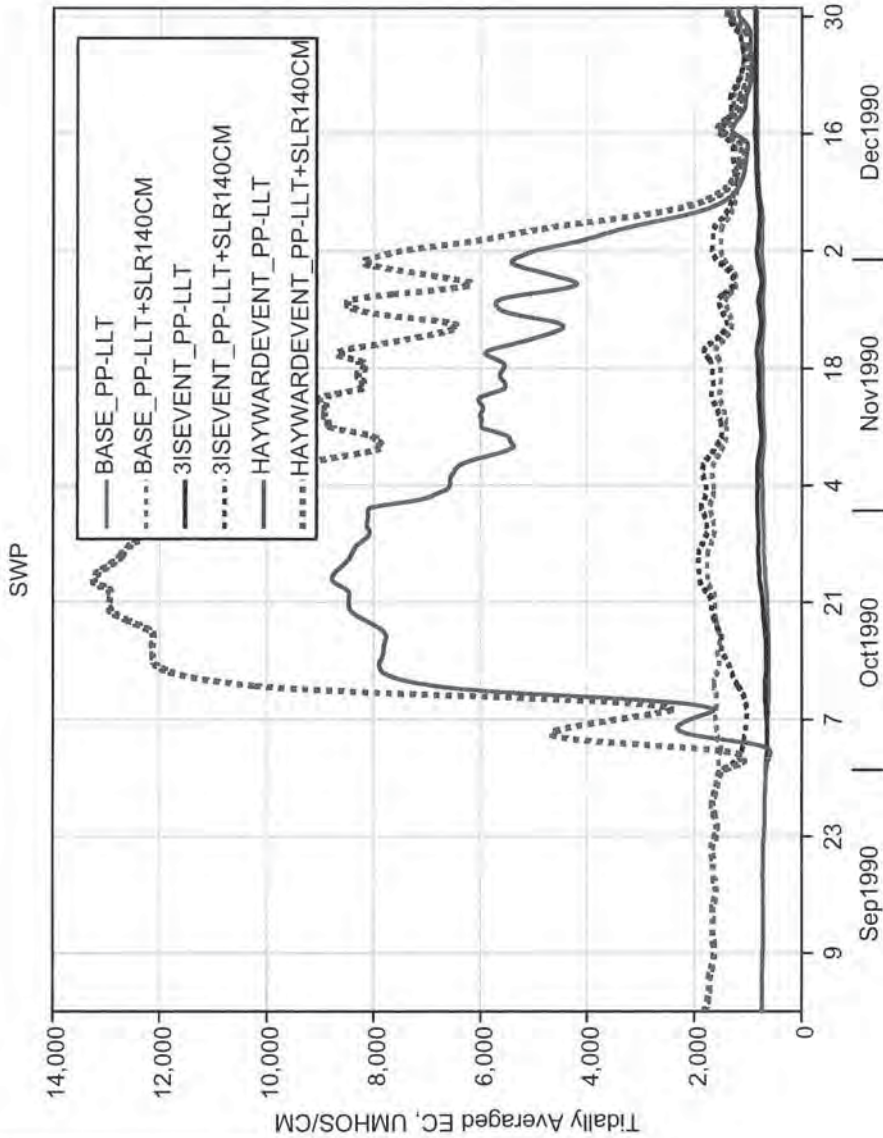


Tidally Averaged EC, Sep 1 to Dec 31, 1990

Base, 3 Is Event, Hayward Event



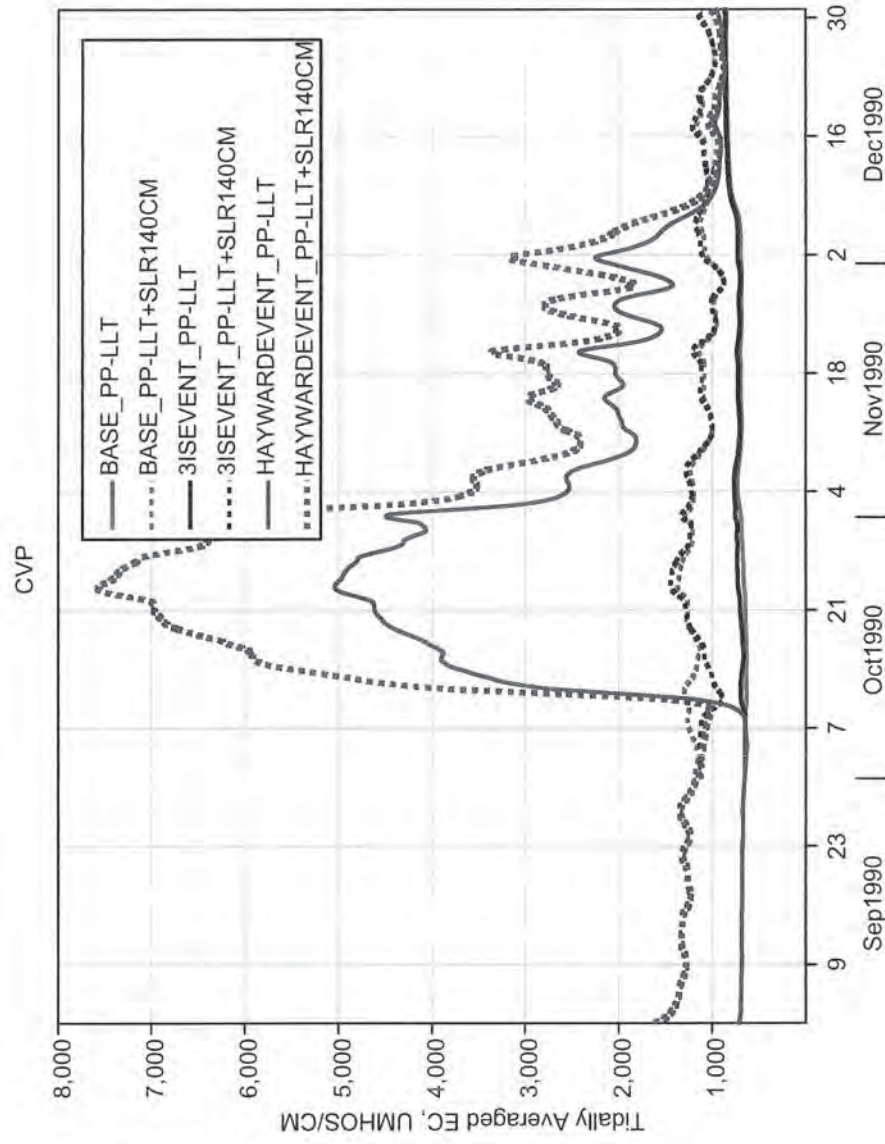
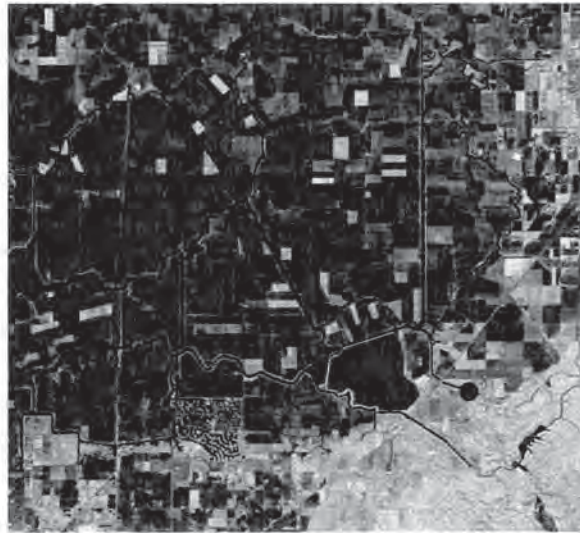
SWP



Tidally Averaged EC, Sep 1 to Dec 31, 1990

No Breach, 3 Is Event, Hayward Event

CVP



Long-Term Levee Failure Analysis

Model Assumptions

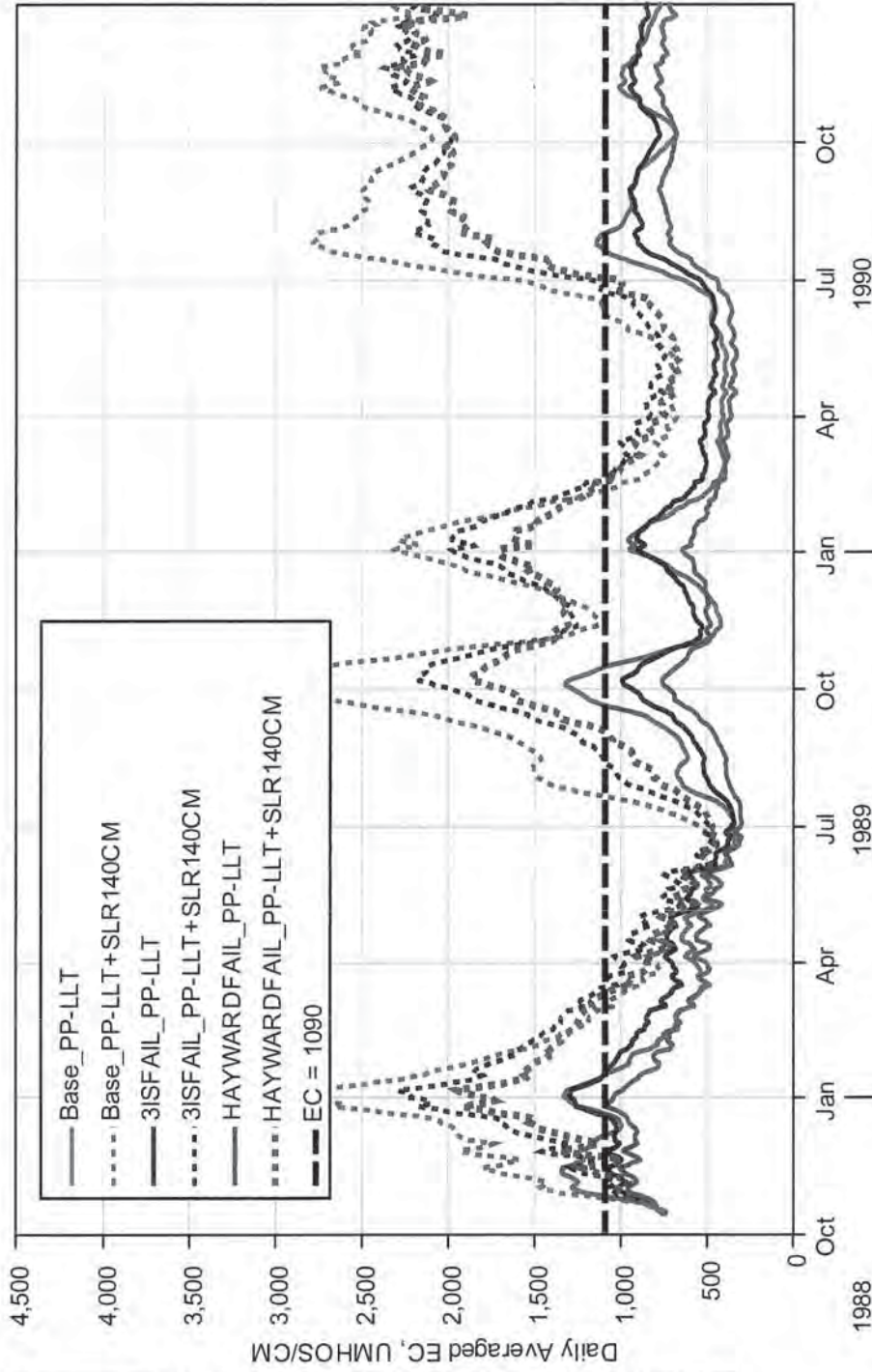
- Simulations were run January 1989 – December 1990 plus a three month spin-up
- Breach event is not simulated – simulations start with breaches open
- Three failure scenarios are considered, all include LLT restoration:
 - No levee failure (all breaches closed)
 - 3 Island failure scenario (plus Grizzly Island failures)
 - Hayward failure scenario (plus Grizzly Island failures)
- Three tidal boundaries are considered
 - Historical Golden Gate tide (no sea level rise)
 - Historical Golden Gate tide plus 140 cm sea level rise
 - Historical Golden Gate tide plus 140 cm sea level rise with 5% amplitude increase (this case not yet complete)

Long-Term Levee Failure Analysis

Model Assumptions (cont.)

- First iteration simulations use all PP-LLT inflow and export boundary conditions with no modifications
- Second iteration simulations:
 - SWP and CVP exports turned off when EC at RMID015 or ROLD024 > 1090 umhos/cm
 - These export flows are transferred to the Isolated Facility up to its potential capacity
 - All scenarios reach the 1090 limit, requiring the second iteration, except the Hayward scenario with no SLR

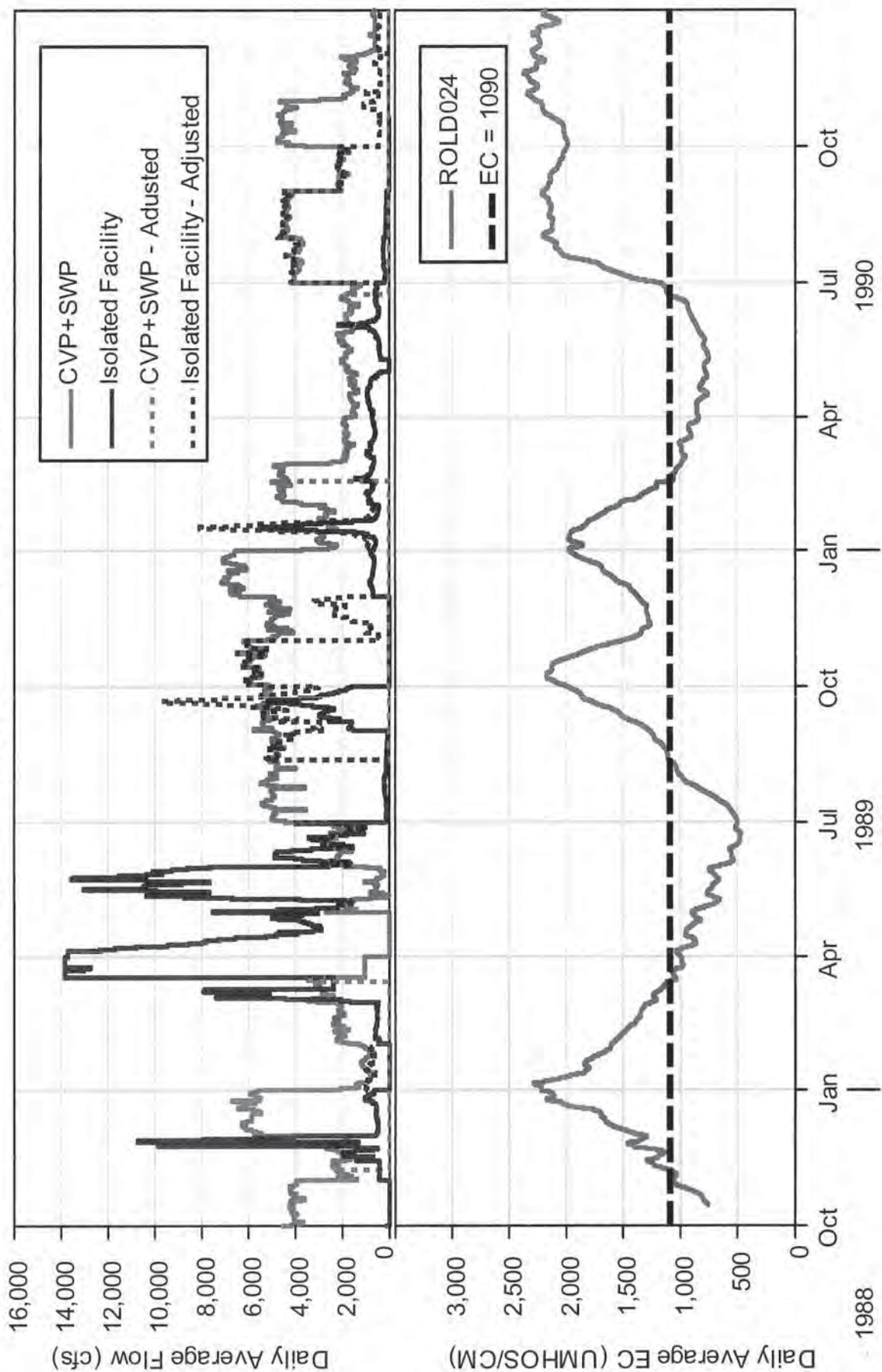
Daily Averaged EC at ROLD024

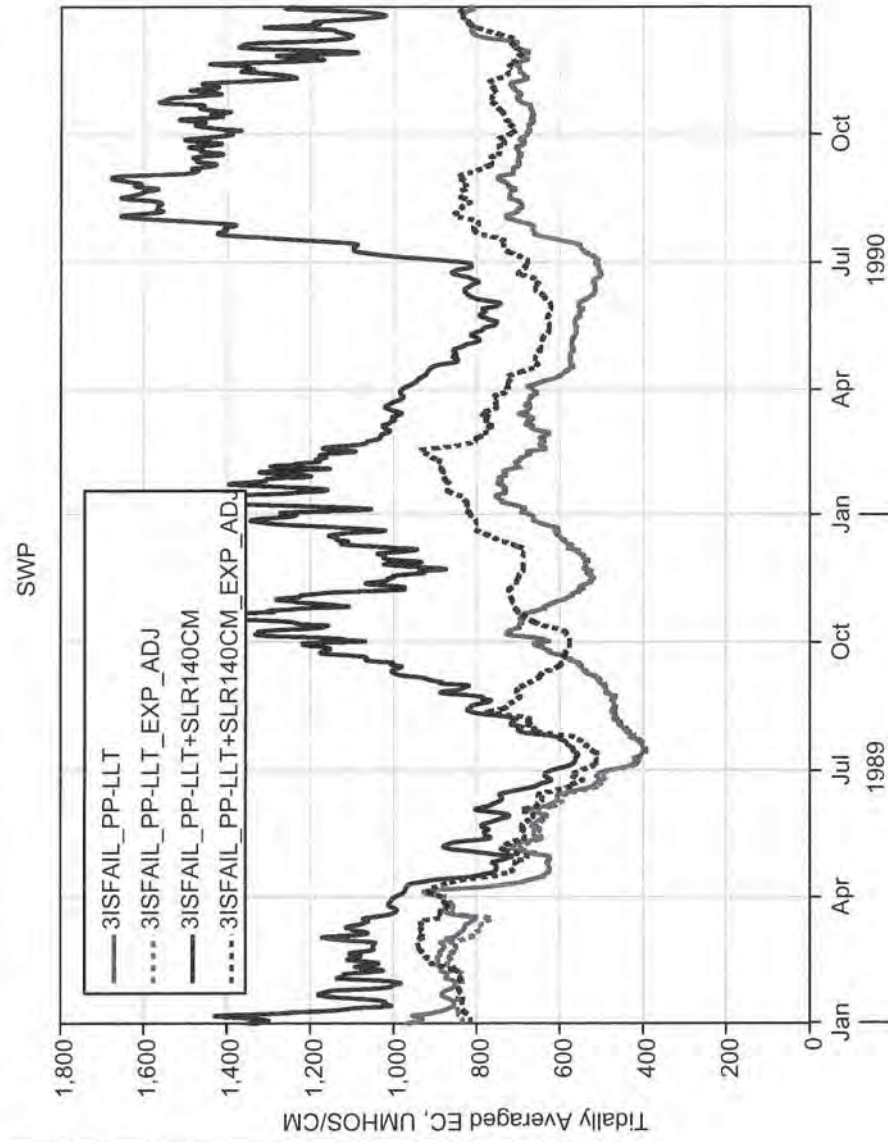


- With 140 cm SLR, EC frequently exceeds 1090 umhos/cm, thus export adjustments are significant
- Without SLR, periods of export adjustment are brief for Base and 3 Island cases
- No export adjustments are made for the Hayward case with no SLR

2nd Iteration Export Adjustments

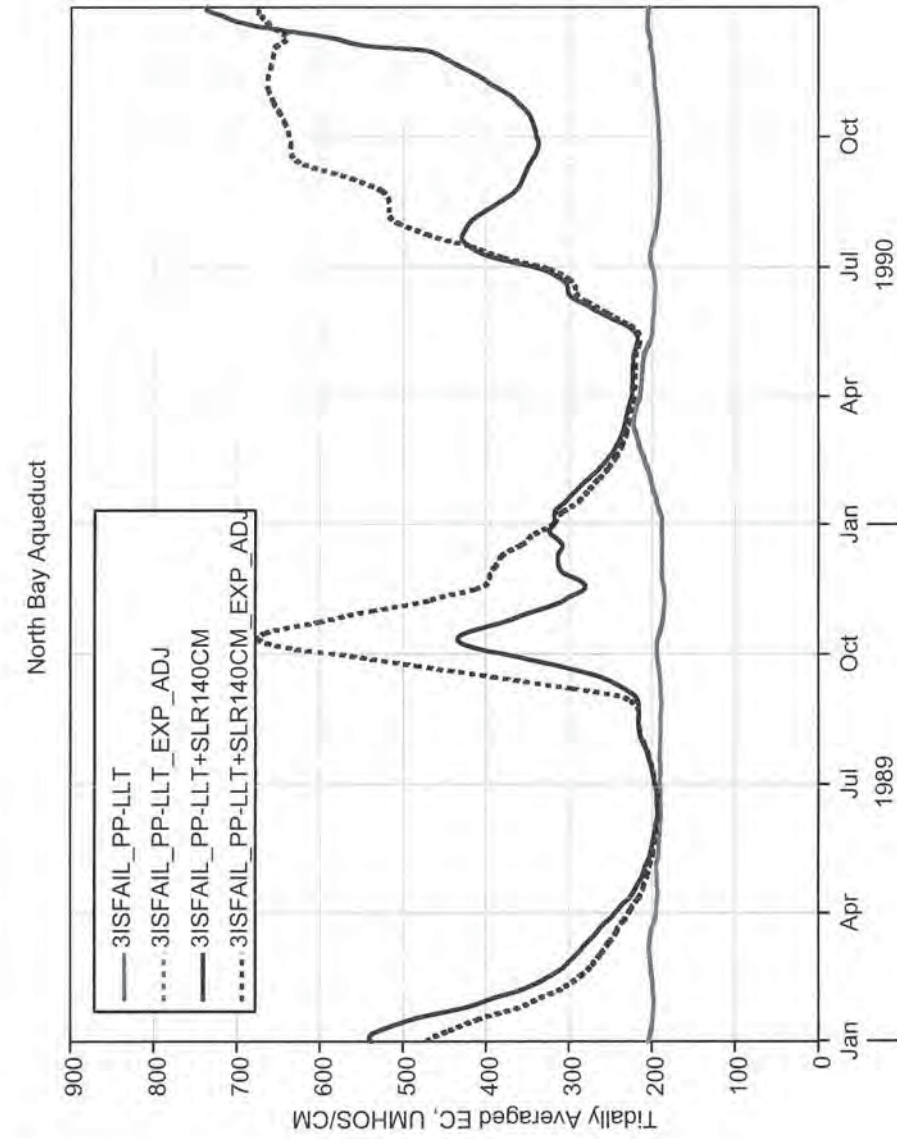
3 Island Failure + 140 cm SLR





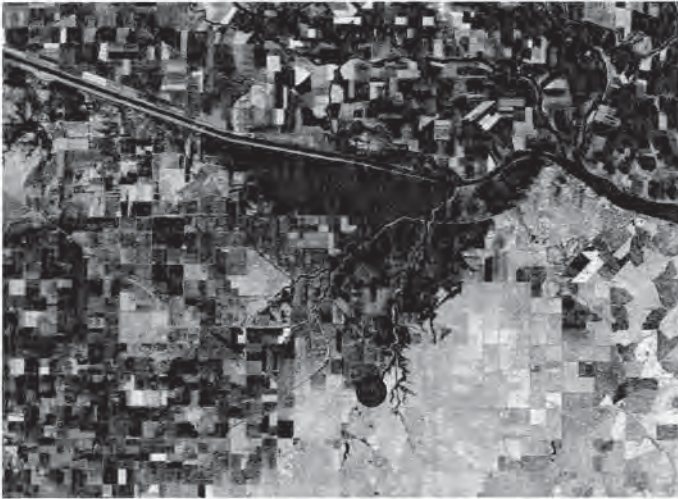
Clifton Court Intake Channel, SWP , 3 Island simulation :

- Export adjustment reduces south Delta EC for SLR 140 cm case.



North Bay Aqueduct, 3 Island simulation:

- Export adjustment tends to increase EC in the Cache Slough area for SLR 140 cm case.



Levee Failure Analysis

EC Results Summary

Isolated facility

- EC is not impacted by open breaches, 140 cm sea level rise or export adjustments

Cache Slough area

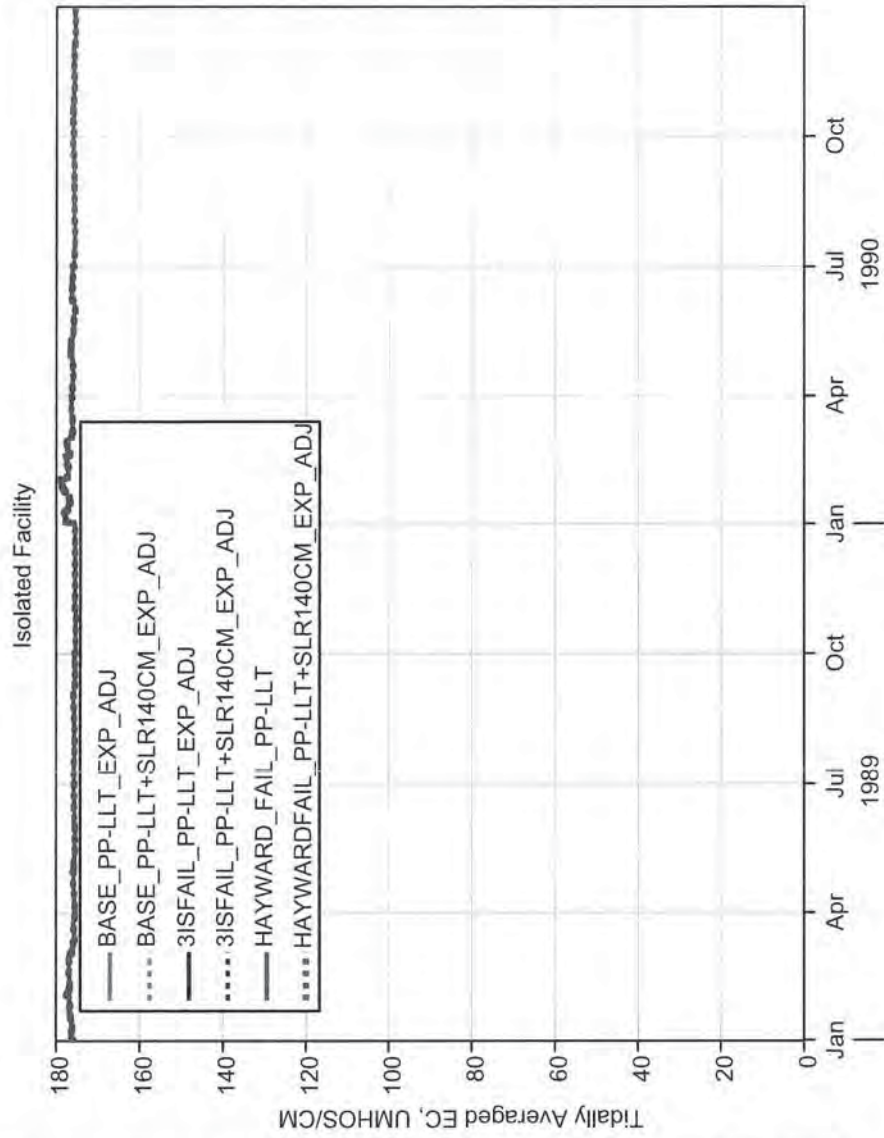
- EC is significantly increased by 140 cm sea level rise
- Open breaches result in decreased EC or minor EC increases in this area
- Export adjustments increase EC in this area

South Delta

- EC is significantly increased by 140 cm sea level rise
- Open breaches result in decreased EC or minor EC increases in this area
- Reduction of south Delta exports reduces EC for sea level rise cases
- Due to small changes in exports for the cases without SLR, EC changes are small
- With SLR, export reduction is less effective in reducing EC in Old and Middle River for the Hayward case

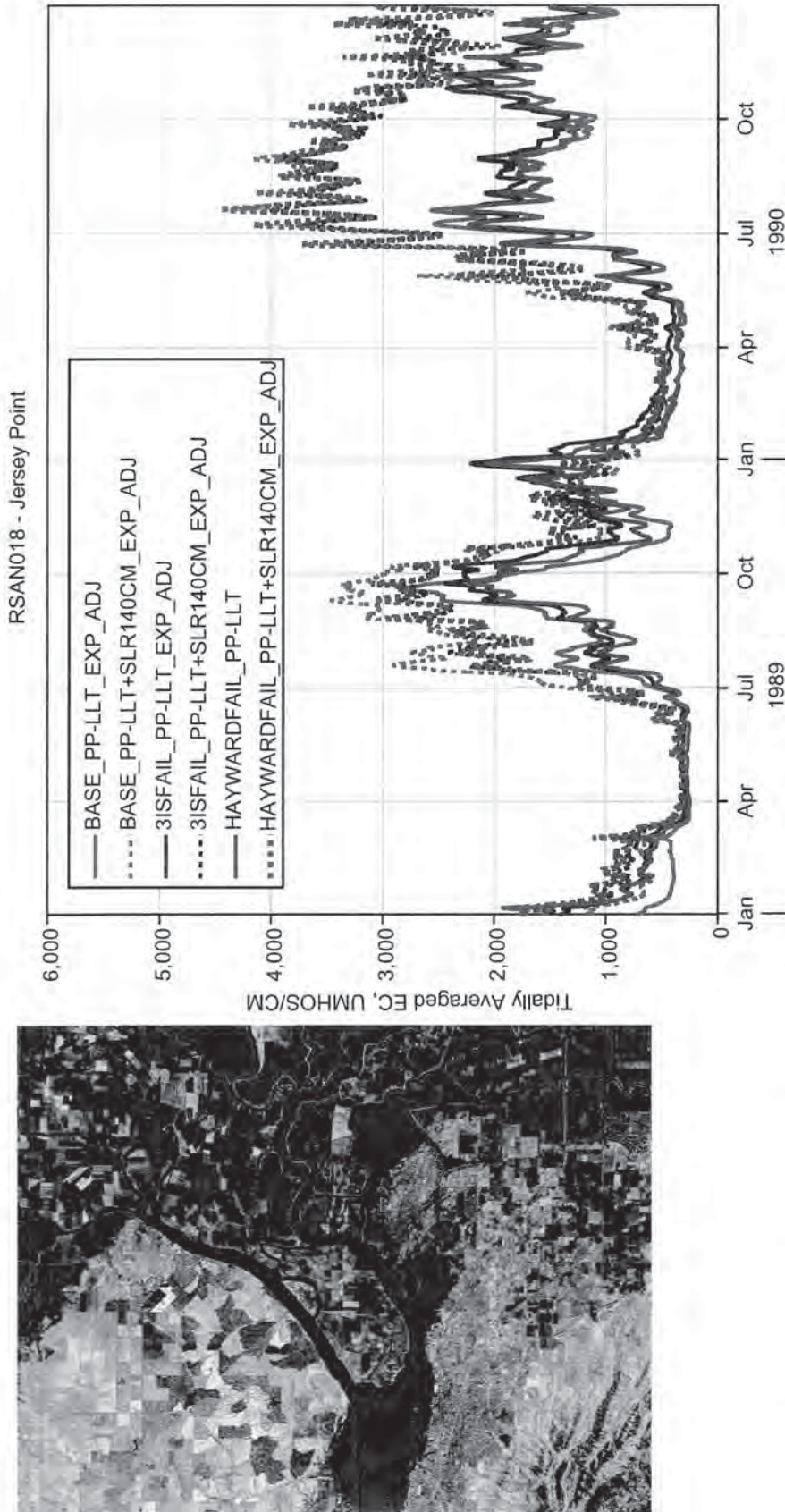
Montezuma Slough

- EC is significantly increased by 140 cm sea level rise
- EC is significantly increased by both failure scenarios
- Grizzly Island failures are the same for both scenarios, thus results are similar



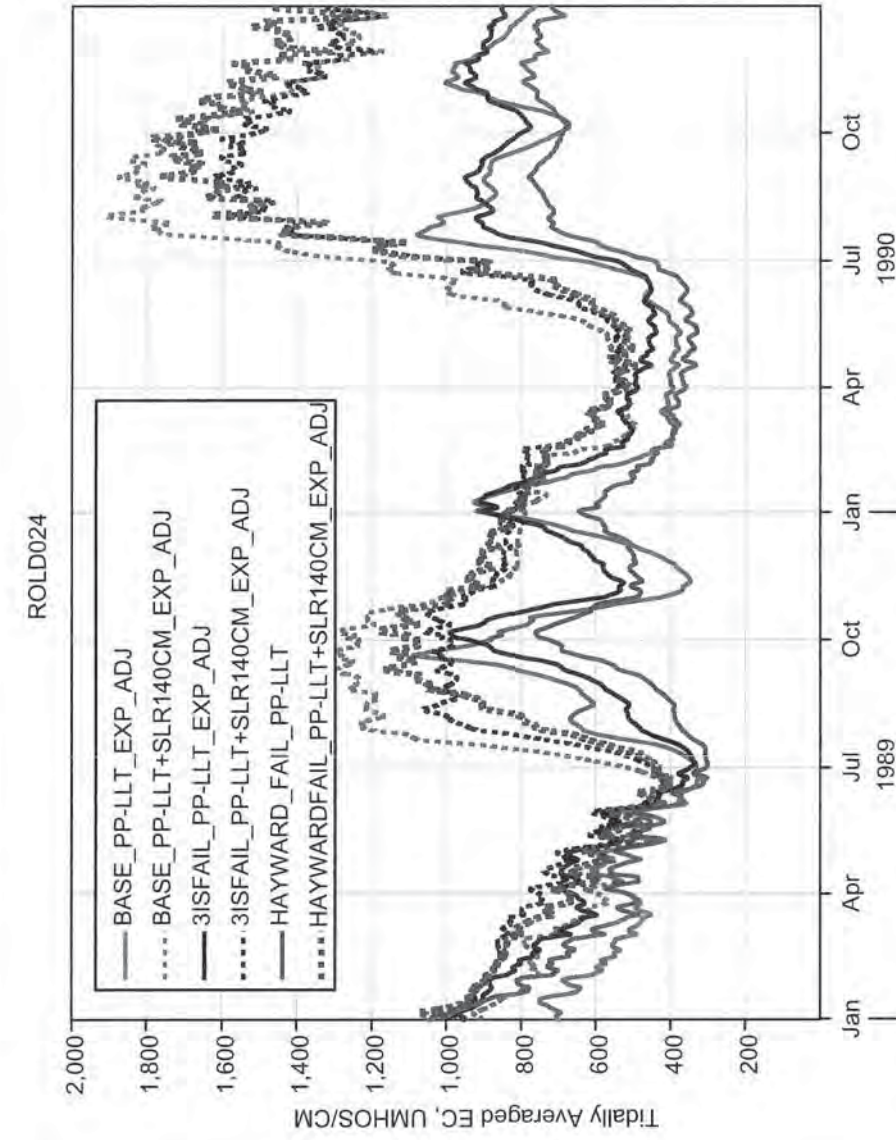
Isolated Facility:

- No significant impacts from SLR or Levee Failure.



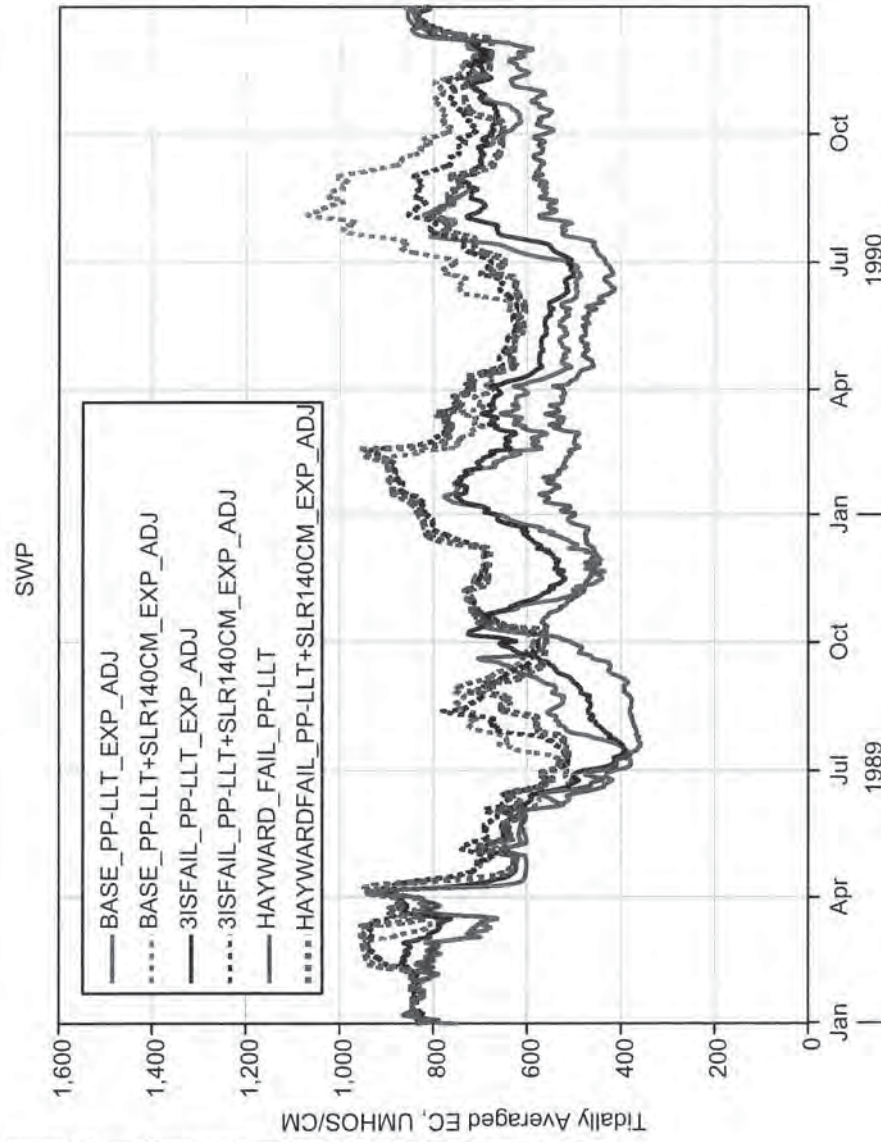
RSAN018 – Jersey Point:

- 140cm SLR increases EC significantly at times.
- Differences between EC results with and without SLR are reduced due to export adjustments.
- With and without SLR, impacts of both breach cases vary seasonally.
- With SLR, the impacts of both failure cases vary seasonally.
- With SLR, the Hayward case is slightly less responsive to export reductions.



ROLD024 – Old River at Rock Slough:

- 140cm SLR tends to increase EC.
- With no SLR, the Hayward case tends to decrease EC. Impacts of the 3 Island case vary seasonally.
- With SLR, both failure cases tend to decrease EC.
- With SLR, the Hayward case is less responsive to export reductions.



Clifton Court Intake Channel, SWP:

- 140cm SLR tends to increase EC.
- With no SLR, the Hayward case tends to decrease EC. Impacts of the 3 Island case vary seasonally.
- With SLR, both failure cases tend to decrease EC. Hayward case results in greatest decreases.

Levee Failure Analysis

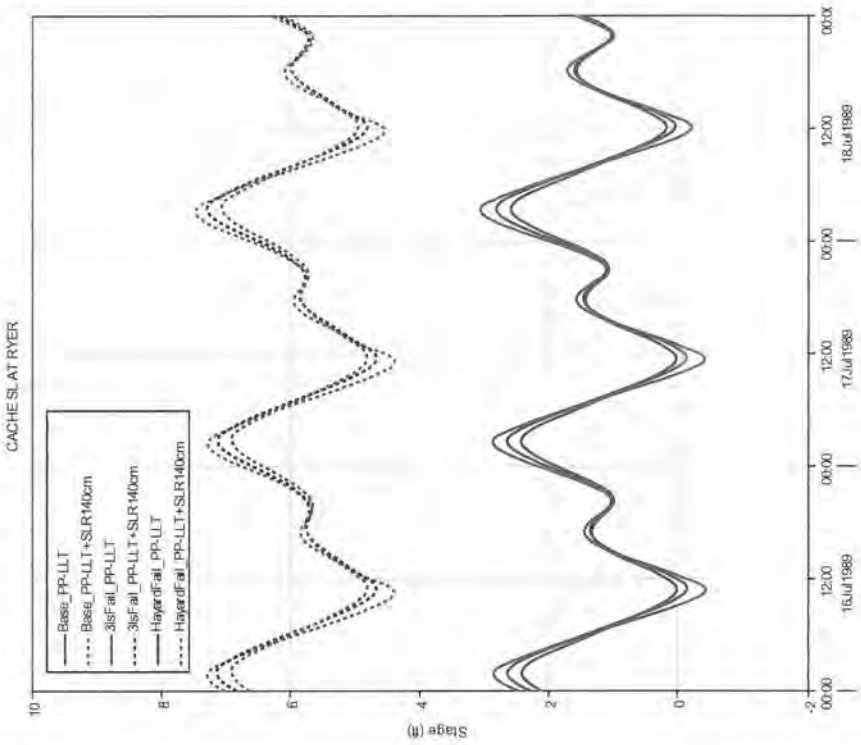
Tidal Marsh Impacts Summary

- Both breach cases reduce tidal range
- The Hayward case tends to have the greatest impact on tidal range
- In Suisun Marsh, the Grizzly Island breaches have the most important impact, thus results for both breach cases are similar
- Sea level rise shifts most of the ROA area to Below MLLW and leaves minimal area Above EHW
- With no sea level rise, breach cases reduce MHHW-EHW and MLLW-MHHW areas for all ROAs due to reduction in tidal range
- With 140 cm SLR, MLLW-MHHW areas for all ROAs are either reduced or show very little change
- Change in area between MLLW and EHW due to SLR depends on topography
- In some cases, the model boundaries limit the area above MHHW

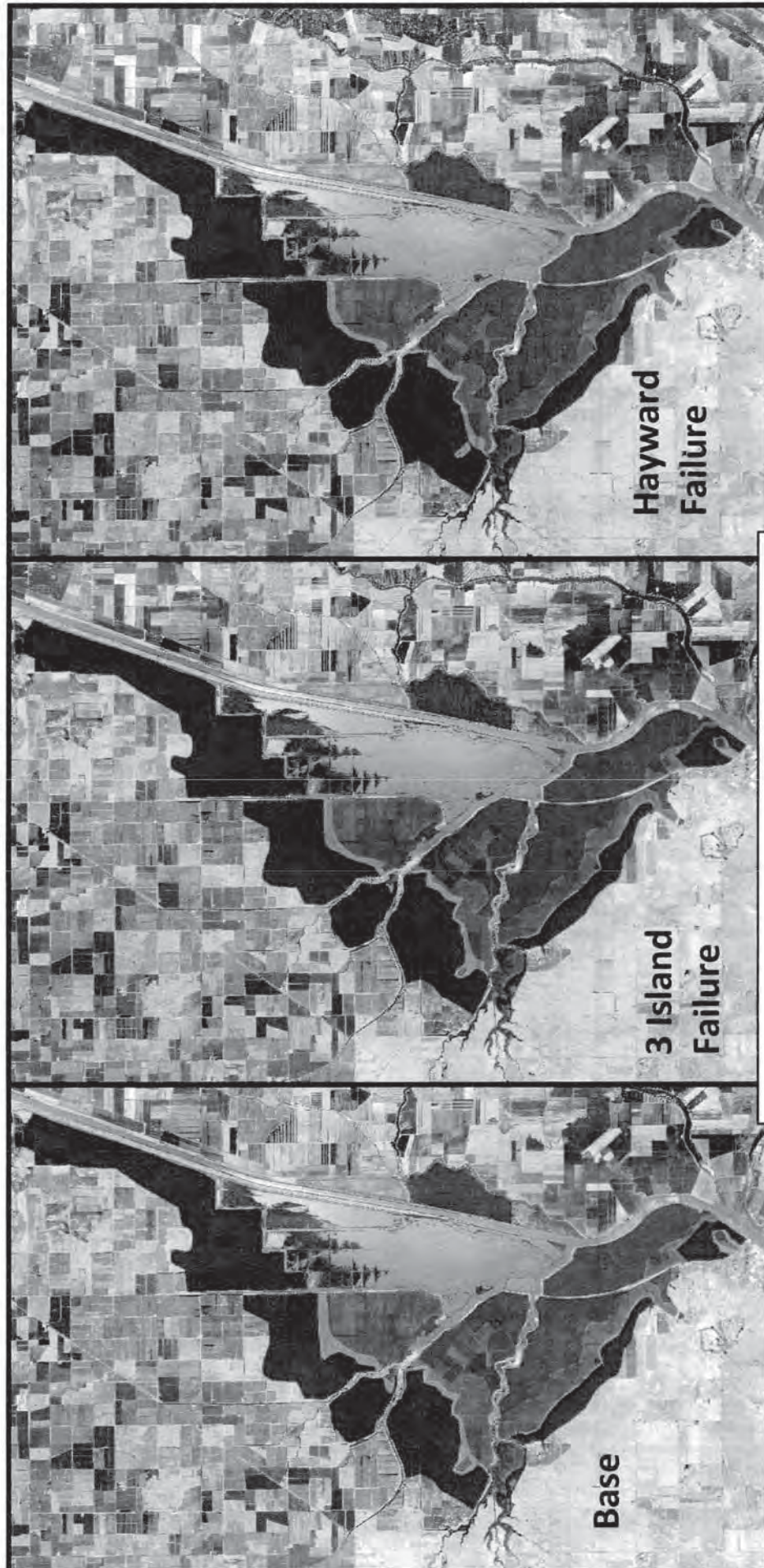
Cache Slough Tidal Datum areas in Acres						
No SLR			140 cm SLR			
	Base	3 Island	Hayward	Base	3 Island	Hayward
Above EWH	12,275	12,899	13,369	8	8	102
MHHW-EHW	1,128	987	863	184	545	703
MLLW-MHHW	6,613	5,716	5,162	4,850	4,274	3,940
Below MLLW	6,397	6,811	7,019	21,371	21,586	21,668

Cache Slough:

- Sea level rise inundates much of the ROA shifting the majority of the area to Below MLLW
- Both breach cases reduce tidal range in Cache Slough
- The Hayward cases has slightly more impact on tidal range



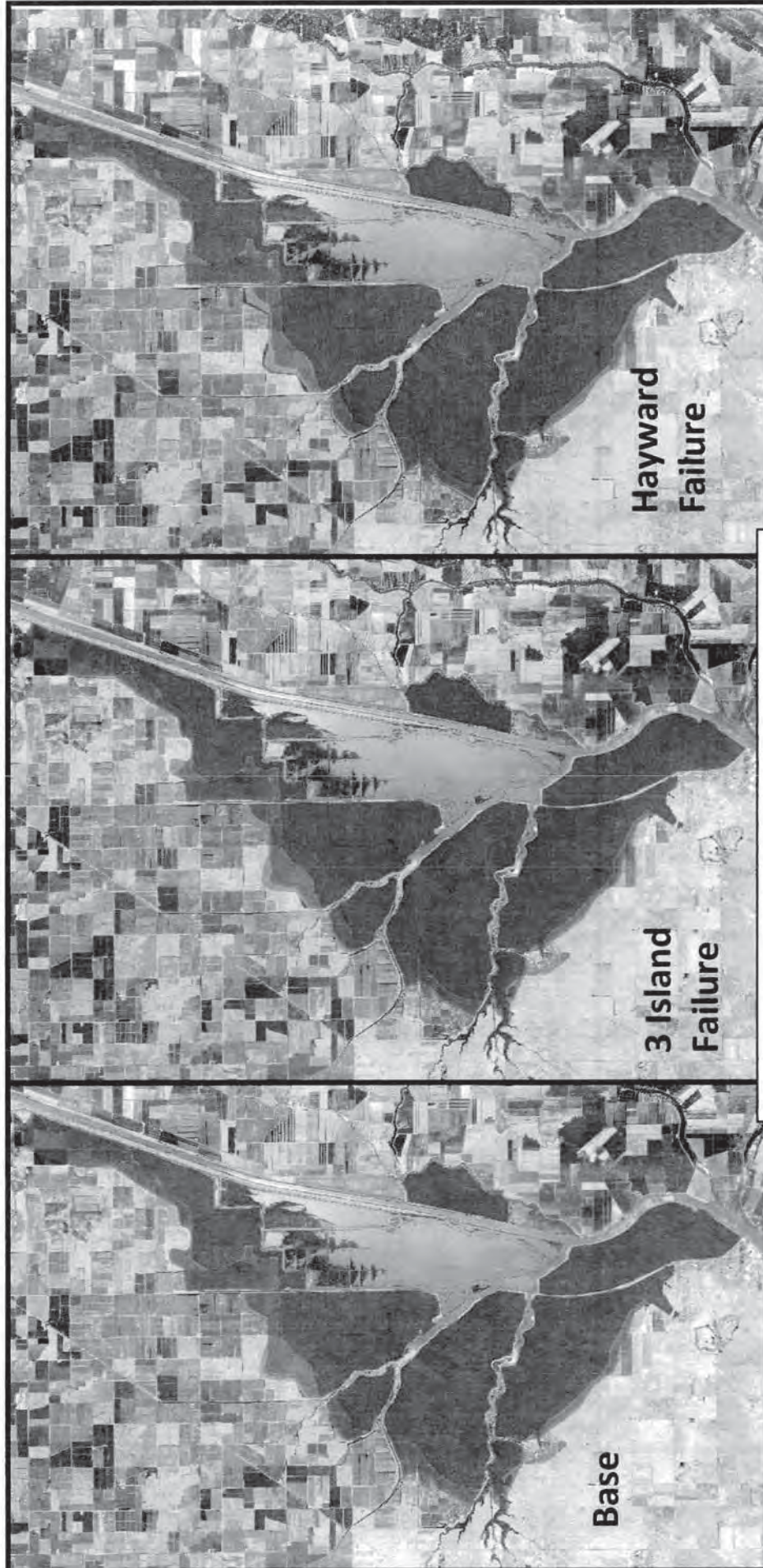
Cache Slough ROA No SLR



BDCP1563.



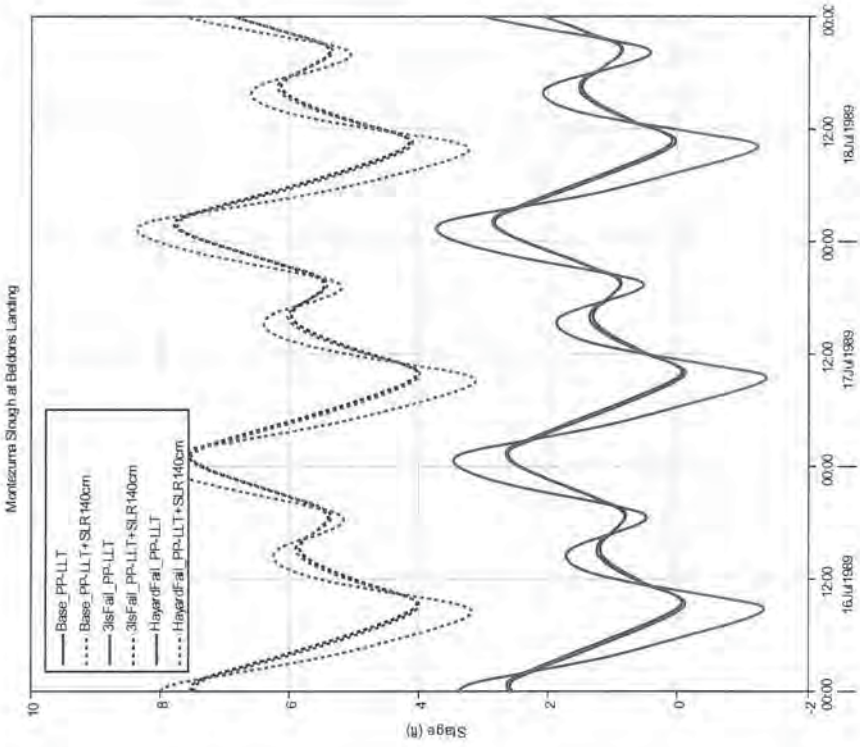
Cache Slough ROA With 140 cm SLR



	Suisun Marsh Tidal Datum areas in Acres					
	No SLR			140 cm SLR		
	Base	3 Island	Hayward	Base	3 Island	Hayward
Above EWH	1,449	2,608	2,623	-	23	32
MHHW-EHW	909	544	522	16	171	168
MLLW-MHHW	4,647	2,516	2,557	1,562	904	921
Below MLLW	9,088	10,423	10,390	14,513	14,993	14,970

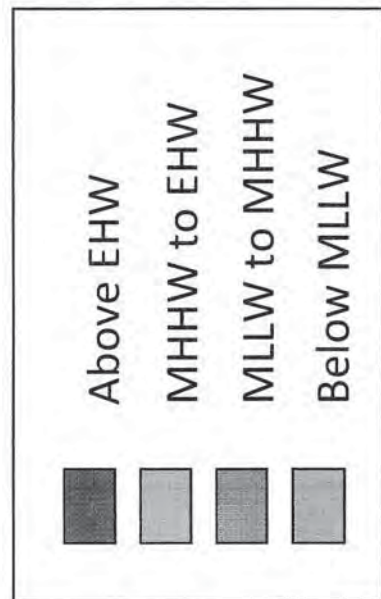
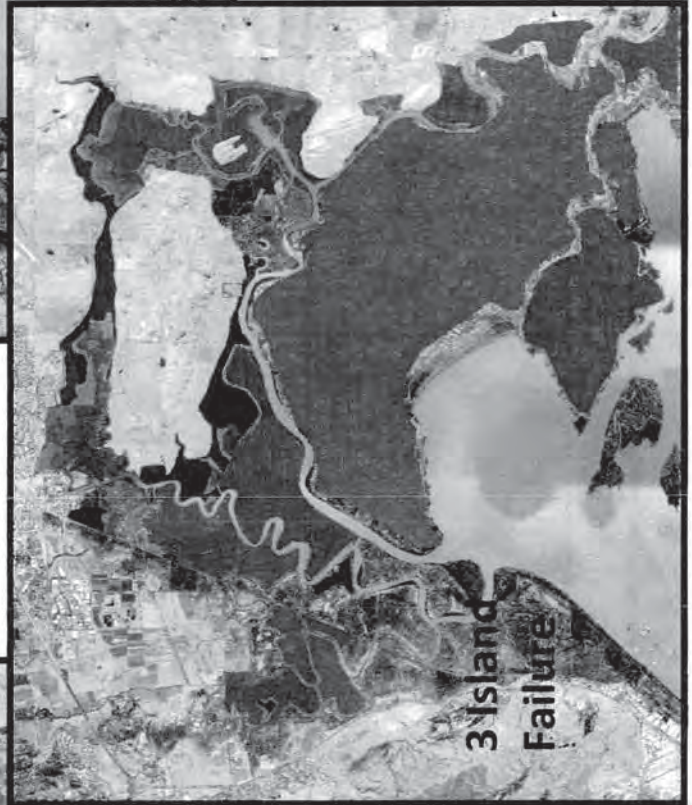
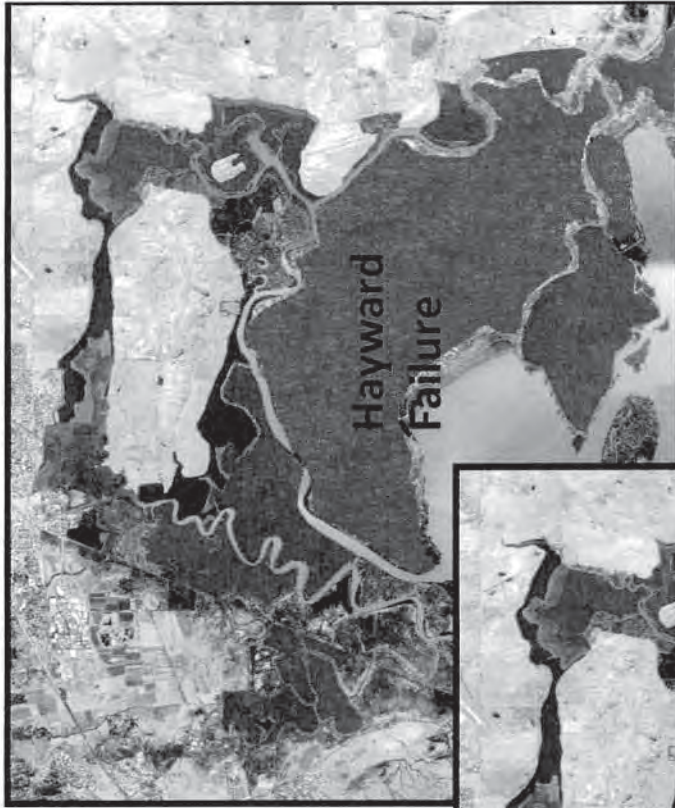
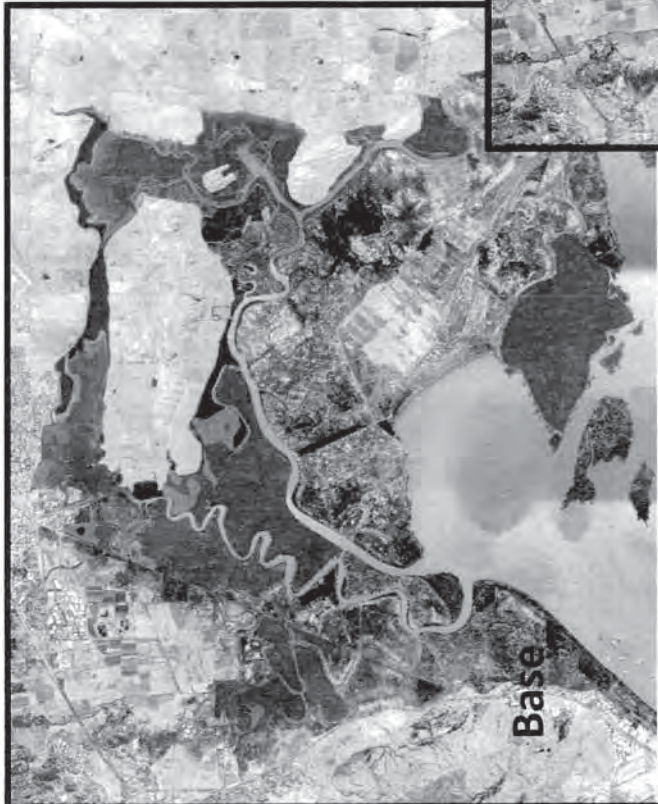
Suisun Marsh:

- Sea level rise inundates much of the ROA shifting the majority of the area to Below MLLW
- Grizzly Island breaches significantly reduce the tidal range
- Delta breaches have minimal impact in Suisun Marsh in these cases



Suisun Marsh ROA

No SLR



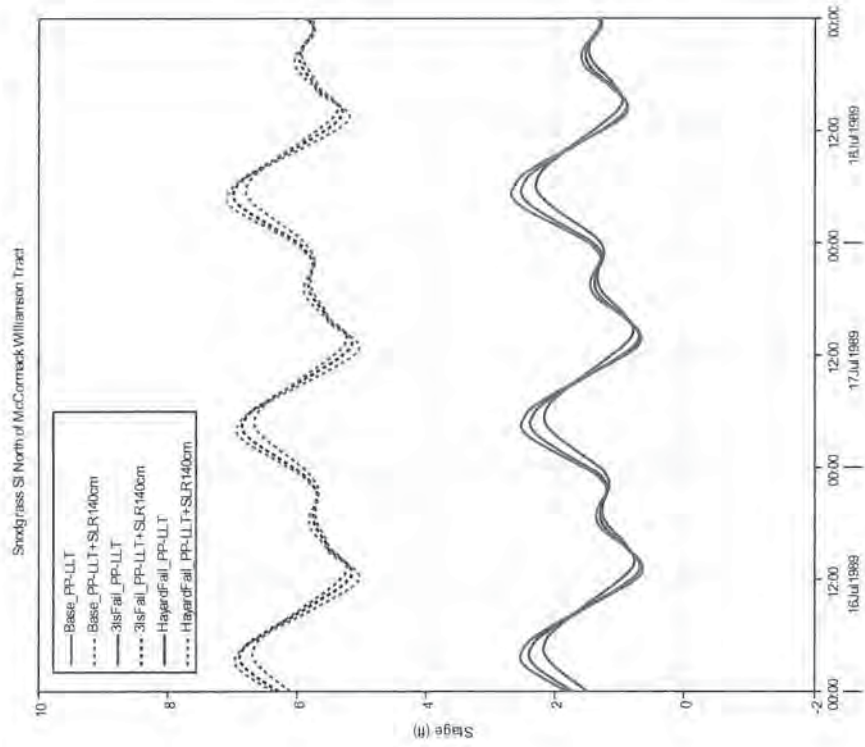
	Mokelumne-Cosumnes Tidal Datum areas in Acres					
	No SLR			140 cm SLR		
	Base	3 Island	Hayward	Base	3 Island	Hayward
Above EWH	1,997	2,093	2,230	164	194	222
MHHW-EHW	235	233	233	72	62	62
MLLW-MHHW	1,382	1,241	965	396	371	329
Below MLLW	1,405	1,451	1,591	4,386	4,392	4,406

Mokelumne-Cosumnes:

- Sea level rise inundates much of the ROA shifting the majority of the area to Below MLLW

- Both breach cases slightly reduce tidal range in the Mokelumne-Cosumnes ROA

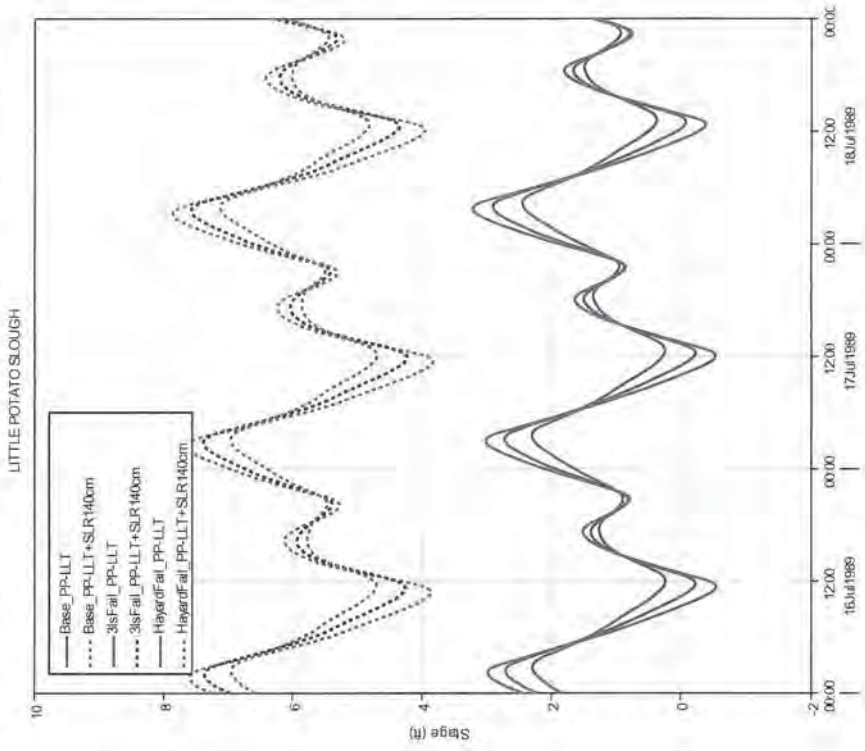
- The Hayward cases has slightly more impact on tidal range



	East Delta Tidal Datum areas in Acres					
	No SLR			140 cm SLR		
	Base	3 Island	Hayward	Base	3 Island	Hayward
Above EWH	1,221	1,254	1,325	-	47	47
MHHW-EHW	105	90	31	47	1	-
MLLW-MHHW	171	154	130	205	205	197
Below MLLW	841	841	852	2,086	2,086	2,093

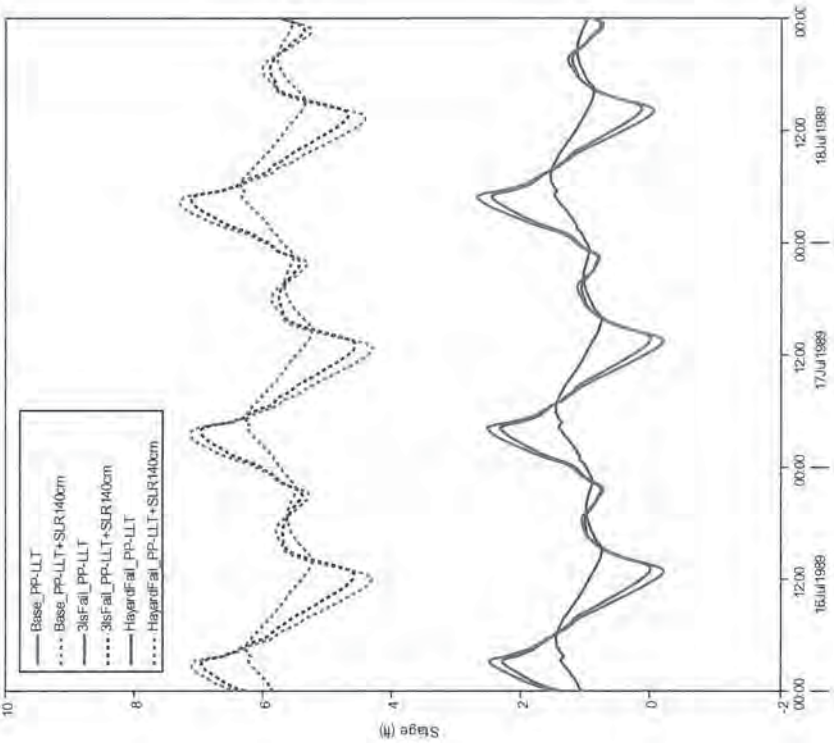
East Delta:

- Sea level rise inundates much of the ROA shifting the majority of the area to Below MLLW
- Both breach cases slightly reduce tidal range in the East Delta ROA
- The Hayward cases has slightly more impact on tidal range



	South Delta Tidal Datum areas in Acres					
	No SLR			140 cm SLR		
	Base	3 Island	Hayward	Base	3 Island	Hayward
Above EWH	10,207	10,332	10,799	-	-	-
MHHW-EHW	666	662	518	-	-	-
MLLW-MHHW	2,547	2,188	840	-	-	-
Below MLLW	9,065	9,303	10,330	22,485	22,485	22,485

RM1D023



South Delta:

- Small tidal range results in minimal area between MLLW and EHW with no SLR
- Sea level rise inundates much of the ROA shifting most of the area to Below MLLW
- Both breach cases reduce tidal range in the South Delta ROA
- The Hayward case has more impact on tidal range with extreme damping in Middle River

Questions?

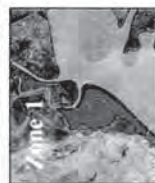
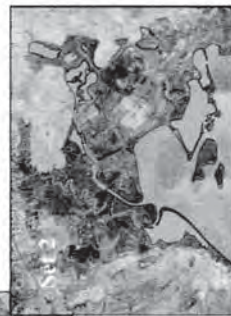
Recent Projects Modeling Local and Regional Impacts of Tidal Marsh Restoration

- * Suisun Marsh Programmatic EIR/EIS
- * Bay Delta Conservation Plan
- * Prospect Island

Resource Management Associates Modeling Team

John DeGeorge, Ph.D., P.E.	Stacie Grinbergs, P.E.
Donald Smith, P.E.	Marianne Guerin, Ph.D.
Richard Rachiele, M.S.	Stephen Andrews, Ph.D.
Edward Gross, Ph.D.	

Delta Independent Science Board Meeting
January 17, 2013



Modeling for the Suisun Marsh Programmatic EIR/EIS

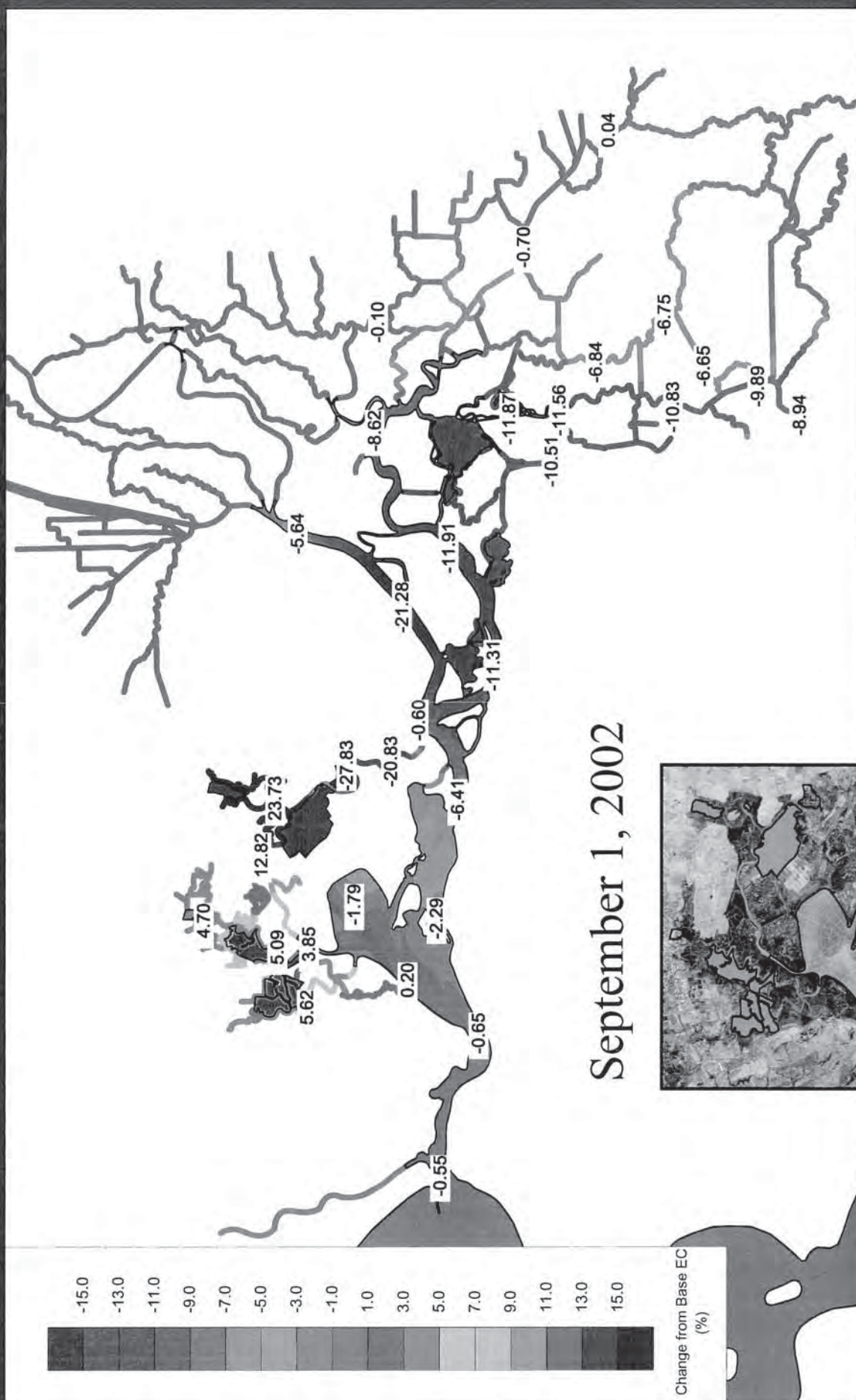


Work performed in 2007-8

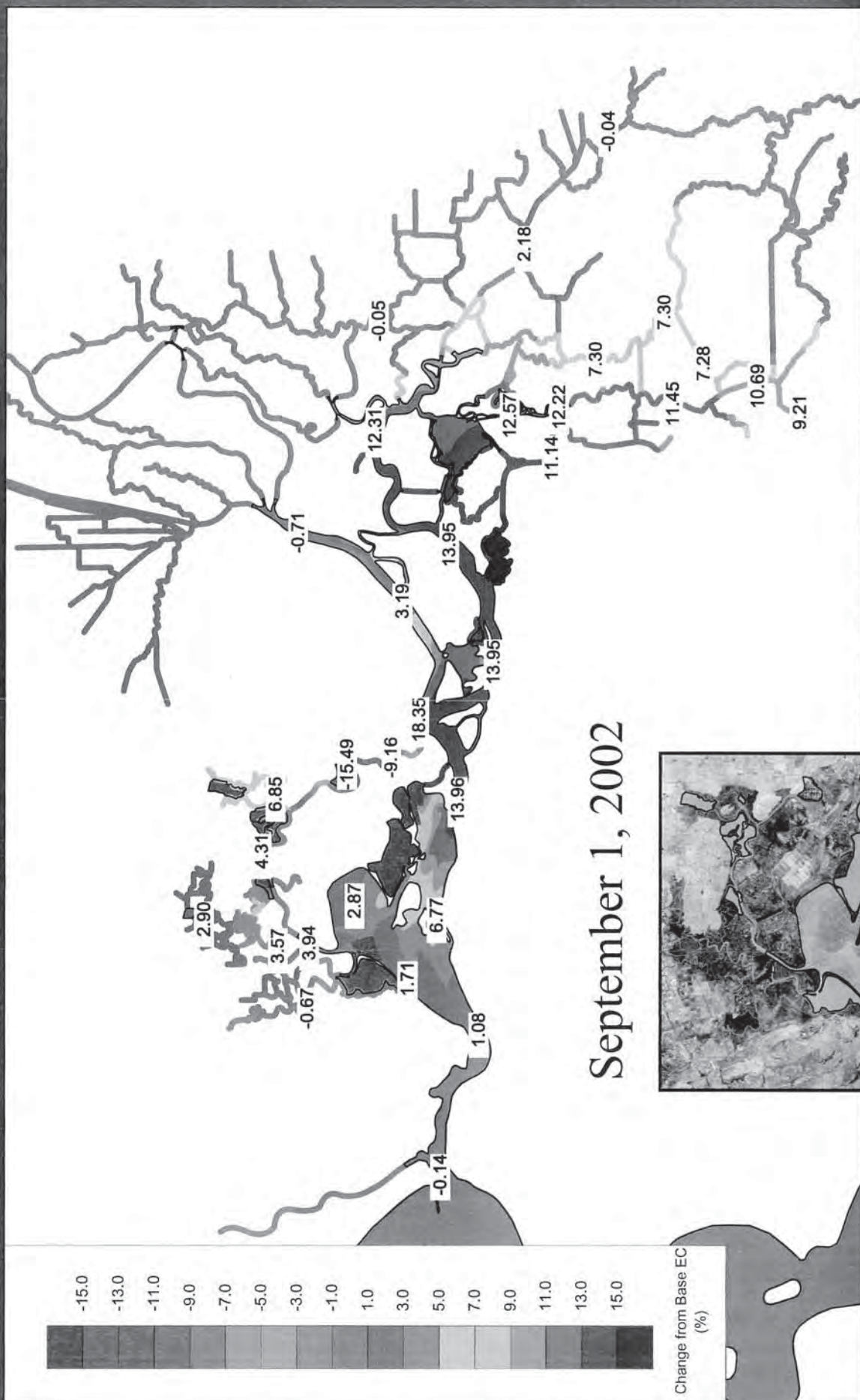
Alternative Comparison



Set - EC Change Fro Base Septe ber ,

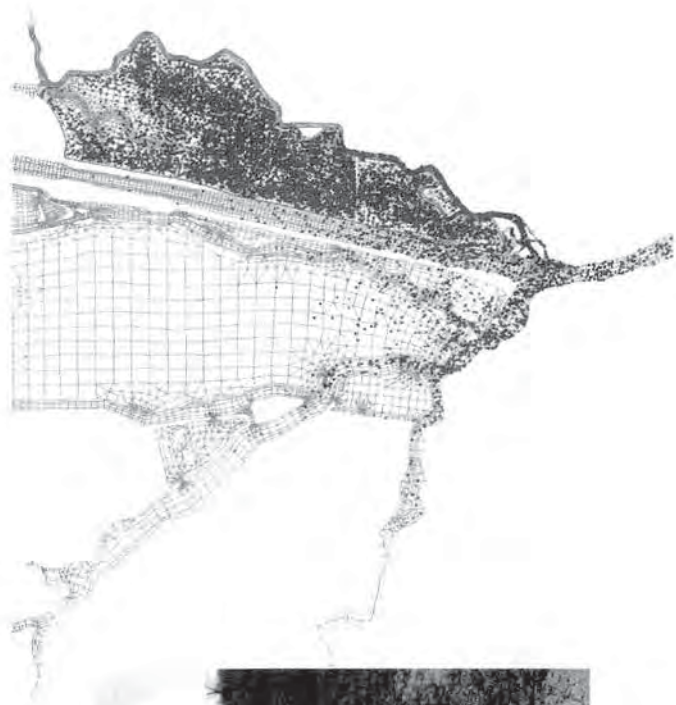


Set - EC Change Fro Base September ,



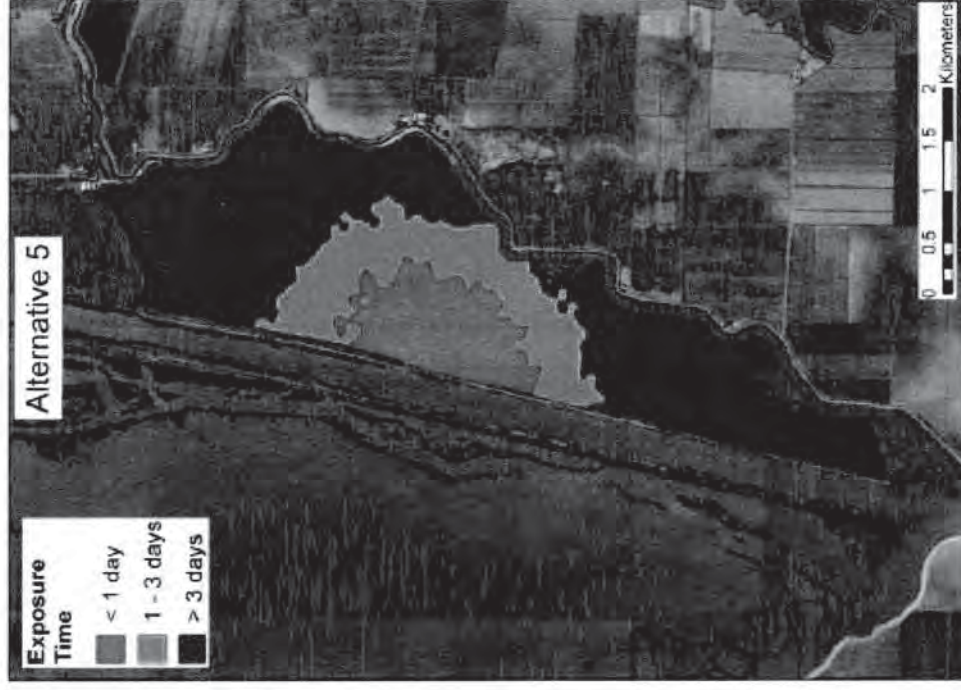
Evaluating Productivity Potential for Prospect Island Restoration Alternatives using Particle Tracking Methods

Stephen Andrews, Richard Rachiele, John DeGeorge

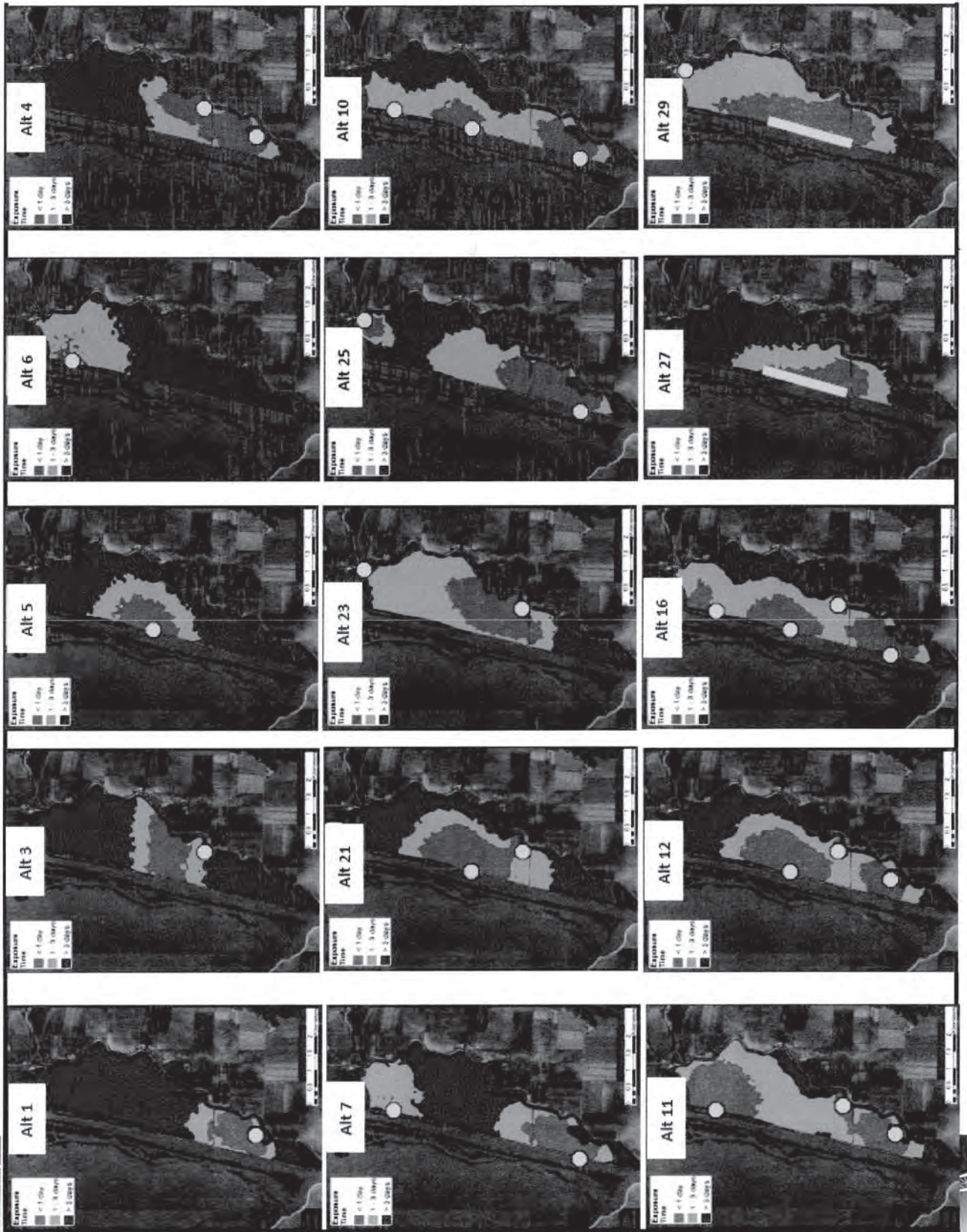


Metrics for Assessing Alternative Performance

- Focus on exposure time within a specific optimal time range
 - 1 to 3 days
 - Enough time to support diatom production
 - Not enough to support Cyanobacteria production



Exposure Time Maps



DELTA WETLANDS PROJECT PLACE OF USE

Final Environmental Impact Report

Prepared for
Semitropic Water Storage District

August 2011



ESA

TABLE OF CONTENTS

Delta Wetlands Project Place of Use Final Environmental Impact Report

	<u>Page</u>
1. Introduction	1-1
1.1 Introduction	1-1
1.2 Summary of Proposed Project	1-1
1.3 Public Participation and Environmental Review Process	1-3
1.4 CEQA Certification and Project Approval	1-4
1.5 Organization of FEIR	1-4
2. Summary of Text Changes to the DEIR	2-1
2.1 Introduction	2-1
3. Responses to Comments	3-1
 Appendices	
A Water Quality Management Plan	
B Mitigation Monitoring and Reporting Program	

DEPARTMENT OF WATER RESOURCES

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



JUN 9 8 2010

Ms. Megan Smith
Project Manager
ICF International
630 K Street, Suite 400
Sacramento, California 95814

Dear Ms Smith:

The Department of Water Resources (DWR) submits the attached comments on the "Delta Wetlands Place of Use Draft Environmental Impact Report" (Draft EIR) dated April 2010 (SCH #1988020824). The enclosed document repeats some of the comments the DWR had provided on 1) January 9, 2009 for the Notice of Preparation for the Draft EIR and 2) August 2, 2000 for the May 2000 REIR/EIS.

DWR's comments address concerns about the potential impacts to the State Water Project (SWP) and other DWR activities where additional information and analysis is needed to more fully understand the proposed project. The Draft EIR does not fully disclose the impacts nor adequately evaluate and address the mitigation measures that may affect the SWP. Specifically, we have concerns about 1) the potential water quality and operational impacts to the SWP and 2) the levee stability and climate change analyses.

I hope these comments are helpful in responding to DWR's concerns. If you have any questions about our comments, please contact me at (916) 654-7180 or your staff may contact Stephen A. Cimperman, Supervising Engineer, Division of Statewide Integrated Water Management, at (916) 651-9285 or stephenc@water.ca.gov.

Sincerely,

A handwritten signature in dark ink, appearing to read 'Dale K. Hoffman-Fiberke'.

Dale K. Hoffman-Fiberke
Deputy Director

Enclosure

cc: (See attached list.)

Mr. Wilmar L. Boschman
Semitropic Water Storage District
1101 Central Avenue
Wasco, California 93260-0877

State Clearinghouse
Office of Planning and Research
1400 Tenth Street, Room 121
Sacramento, California 95814

Mr. Michael Chotkowski
U.S. Bureau of Reclamation
2800 Cottage Way
Sacramento, California 95825

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

**The Department of Water Resources Comments on the Draft Delta Wetlands Place
of Use Environmental Impact Report, April 2010**
Prepared by ICF International, Sacramento, CA

Project Description and Alternatives – Chapter 2

Water Conveyance Contracts

A sentence should be added to Chapter 2 of the Delta Wetlands Place of Use Final EIR (Final POU EIR) stating: Water conveyance agreements must be executed among the Department of Water Resources (DWR), Delta Wetlands (DW), and the water agencies involved in the particular water purchase, which include provisions for monitoring to make conveyance quantity decisions related to the transfer.

5-1

Dam Safety Design and Review

The Draft EIR does not contain detailed design drawings suitable for DWR's Division of Safety of Dams (DSOD) review and final determination. Your Draft EIR should be revised to disclose that design documents will be submitted to DSOD for regulatory compliance.

The Delta Wetlands Project proposes water storage facilities in the Central Delta. Based on the limited information provided, the maximum water surface elevation of these facilities may be below elevation four feet. If so, these facilities will not come under our jurisdiction for dam safety. However, more information is needed to determine the jurisdictional status.

As defined in Section 6004 (c), Division 3, of the California Water Code, the levee of an island adjacent to tidal waters in the Sacramento-San Joaquin Delta, as defined in Section 12220, even when used to impound water shall not be considered a dam, and the impoundment shall not be considered a reservoir if the maximum possible water storage elevation of the impounded water does not exceed four feet above mean sea level, as established by the United States Geological Survey 1929 datum."

5-2

If the above criteria are not met, we will evaluate these facilities in accordance with Sections 6002 and 6003, Division 3, of the California Water Code. Per these criteria, dams 25 feet or higher with a storage capacity of more than 15 acre-feet, and dams higher than 6 feet with a storage capacity of 50 acre-feet or more are subject to State jurisdiction. The dam height is the vertical distance measured from the maximum possible water storage level to the downstream toe of the barrier.

If the proposed impoundment structures are subject to State jurisdiction, a construction application, together with plans and specifications, must be filed with the Division of Safety of Dams. All dam safety related issues must be resolved prior to approval of the application, and the work must be performed under the direction of a civil engineer registered in California. Sharon Tapia, our Design Engineering Branch Chief, is responsible for the application process and can be reached at (916) 227-4660. If you have any questions or need additional information, you may contact Office Engineer Randy Fessler at (916) 227-4601.

Project Operations - Chapter 3

Operations Impacts to the State Water Project

As a water right holder junior to DWR's water rights, your project is prohibited from impacting our operations.

5-3

The modeling completed to simulate DW's operations is not consistent with the current Operations Criteria and Plan biological opinions and therefore cannot adequately assess and disclose potential impacts to the Delta and State and Federal export operations.

An operations agreement to formalize real time coordination is needed to enforce existing water rights and prevent impacts to the State Water Project (SWP). This operations agreement should be included as part of the DW Project in the Final POU EIR.

5-3
Cont

Flow and Water Quality Impacts

The State Water Resources Control Board's (SWRCB) Water Rights Decision 1641 (D-1641) requires the SWP and CVP to meet flow and water quality requirements in the Delta. These requirements apply throughout the year at various locations within the Delta. Diversions from the DW Project may affect DWR's ability to help meet these requirements.

One of the requirements is the Habitat Protection Outflow (X2). This requirement begins in February and continues through June having inter-monthly connections. The X2 requirement can be satisfied by meeting either an equivalent flow or salinity concentration at Chipps Island or Port Chicago. If the standard is met for greater than the required number of days per month, then the additional days (or credit) can then be applied to the following month's requirement.

In the Water Quality chapter, under the Operations Criteria section, page 30, the first bulleted item describes In-Delta Storage operations that could potentially affect the X2 position.

5-4

The following is an excerpt from this item,

"The Proposed Project would restrict diversions to storage to times when X2 is located at or downstream of Chipps Island. This restriction would have two benefits. It would ensure that the water diverted to storage is of low salinity and it would ensure that diversions to storage are unlikely to have deleterious fish effects associated with potential upstream movement of the X2 location."

The operation may not have deleterious fish effects, but it can cause the X2 position to shift eastward or upstream, which may affect the SWP and CVP's ability to meet the X2 requirements as stipulated in the D-1641 and the US Fish and Wildlife Service Biological Opinion. In addition, credit days are reduced when the DW Project diverts excess water, thereby impacting the two projects. DWR would have to change operations to make up for this deficiency in the following month by either increasing releases of stored water or reducing exports in the Delta to compensate for this eastward shift in X2. The impacts due to the shift in X2 position in any given time period may not be apparent until subsequent time periods. The modeling should be re-evaluated, results disclosed, and mitigation measures for negative impacts included in the Final POU EIR.

Another requirement is the agricultural water quality standards in the western/interior Delta. These standards apply between April 1 and August 15. Again, diversions from the DW Project may have an impact to the SWP; such that, DWR and/or the US Bureau of Reclamation (Reclamation) would have to either increase releases from upstream storage or decrease the exports. The hydrologic modeling should be re-evaluated, results disclosed, and mitigation measures for negative impacts included in the Final POU EIR.

5-5

Indirect Impacts to the SWP Due to Fish Presence

The SWP operations are greatly affected by the fish distribution in the Delta. The fishery agencies determine Old and Middle River flows that in turn directly regulate the SWP's ability to export. They evaluate the estimated fish distributions from observational data, as well as the potential influence of export operations on the fish distribution using a particle tracking model. They make a real-time determination after reviewing the combined Delta exports and its potential to influence the fish distribution. They also incorporate an entrainment risk assessment.

5-6

The DW Project's combined diversion rate is on the same order of magnitude as the Banks and Jones pumping plants. It appears that the additional diversions from the DW Project could increase the

presence of fish within the central and southern Delta. This would encourage the fishery agencies to impose a more positive Old and Middle River flow, thus causing the combined exports to be reduced and negatively impacting the SWP operations.

The diversion measures described on page 7 of Chapter 3, Project Operations, do not adequately cover this issue. In addition, the Protest Dismissal Agreements between DW, DWR, and Reclamation do not adequately cover this issue. The Final POU EIR should contain an assessment of the increased presence of fish within the central and southern Delta due to DW operations and resultant impact on the SWP and CVP exports.

The DW Project's combined diversions are also not required to have a positive flow past their screens during ebb tides to prevent inadvertent movement of smelt from the Cache Slough area. Increased fish presence may cause the fishery agencies to impose higher minimum Old and Middle River flow restrictions thus causing a reduction in SWP pumping rates and impacting SWP operations. The Final POU EIR should contain an assessment of the increased presence of fish within the central and southern Delta due to DW operations and resultant impact on SWP exports.

5-6
Cont

Modeling

In Appendix A, the mathematical modeling for In-Delta Storage Model is described as a post-processing of CalSim model results. The approach of post-processing operations of an In-Delta Storage facility inherently ignores some dynamic changes that would occur due to changes in conditions caused by the In-Delta Storage operations. Diversions into or from the DW Project would necessarily change the flows and thus the water quality in the Delta. These changes would then affect the SWP's real-time response to any such changes. Even small changes in Delta flows could lead to large impacts over time. The only way to control and manage these possible impacts is through enhanced real-time coordination between the DW Project and the SWP and CVP. An operations agreement to formalize real-time coordination is needed to enforce existing water rights and prevent impacts to DWR and Reclamation. This operations agreement should be included as part of the DW Project in the Final POU EIR.

5-7

Water Supply – Section 4.1

Water Transfers

In the Water Supply Chapter, pages 6 (second to the last paragraph on the page), 9 (last paragraph on page), and other locations throughout the document, includes a discussion of exports between September through November for storage in groundwater banks. This may be considered a transfer and partially outside the transfer window, defined as being between July and September, and is not allowed under the DW Project's current biological opinions. The hydrologic modeling should re-evaluate a shortened transfer window, disclose results, and mitigation measures for negative impacts included in the Final POU EIR.

5-8

DWR's Protest Dismissal Agreement (PDA)

A stipulation between DW Properties and the DWR was signed on July 23, 1997 that states operational buffers exist and essentially states that DW would not be able to divert while the Delta is in balanced conditions as defined by the Coordinated Operations Agreement between DWR and Reclamation.

It also states;

"When USBR and DWR have declared the Delta to be in excess water conditions under the COA, no diversion is authorized by permittee greater than the amount of excess water available as reasonably calculated by USBR and DWR."

5-9

The words "reasonably calculated by USBR and DWR" may be insufficient to protect the SWP and CVP for salinity and fish concerns and needs to be addressed. DWR believes an agreement is necessary to define and describe the real-time operations and coordination needed to meet Delta regulatory requirements, and a new PDA negotiated.

5-9
Cont

Water Quality - Section 4.2

Municipal Water Quality Concerns

The Place of Use EIR (POU EIR) (p. 2-15) indicates that the DW Project now incorporates a Water Quality Management Plan (WQMP) that was prepared as part of the water right protest dismissal agreements. Water quality mitigation measures included in the original 2001 FEIR have been eliminated, presumably because project modification (i.e., incorporation of the WQMP) is predicted to reduce impacts to less than significant levels. CEQA Guidelines Section 15147 states, in part, that the information contained in an EIR shall include relevant information sufficient to permit full assessment of significant environmental impacts by reviewing agencies and members of the public. The POU EIR heavily relies on inclusion of the WQMP as a means to avoid impacts to water quality; however, there are many uncertainties associated with the WQMP and the feasibility of its implementation. The uncertainties in the WQMP preclude a full assessment of the potentially significant impacts to drinking water quality. Therefore, the project description, as defined under CEQA, seems incomplete. Furthermore, the POU EIR, including the WQMP, does not appear to identify the full range of potential municipal water quality impacts of the project (e.g., nutrients, taste & odor concerns, bacteria, and unregulated disinfection by-products). The Final POU EIR should evaluate and disclose these potential impacts and specific measures to avoid or mitigate them, or better describe why such impacts are not expected.

5-10

Effectiveness of the Proposed Water Quality Management Plan

The WQMP includes Drinking Water Protection Principles, calls for the establishment of a Water Quality Management Action Board (WQMAB), and the development of Annual Operating Plans subject to approval of the WQMAB. The Annual Operating Plans are to include water quality goals and objectives for diversions and discharges to and from project islands. The Annual Operating Plans will also include a description of the monitoring program, hydrodynamic models, particle tracking models, and the mitigation measures to be implemented by DW to offset any long-term net increase in TOC, TDS, bromide and chloride loading. As written, the WQMP relies on models and monitoring programs that do not currently exist, mitigation measures to be specified at a later time (WQMP, p. 3), and undefined "offsets" (WQMP, p. 7). More detail is needed if the WQMP is to serve as a reliable component of the project that will safeguard against potential impacts to the SWP and Delta water quality. Additional analysis should be completed to define the specific conditions under which DW could discharge water without impacting drinking water supplies. This would include setting limits on DW effluent quality based on ambient hydrologic and water quality conditions in the Delta. Proposed effluent limits should be based on modeling conducted as part of the environmental review process.

5-11

The current approach to mitigation seems inconsistent with CEQA Guideline requirements that state that mitigation measures should not be deferred to a future time (14 Cal. Code Regs., § 15126.4(B)). The CEQA Guidelines indicate that mitigation measures may specify a performance standard that can be met in multiple ways. While the WQMP does include screening criteria it does not include definitive standards that must be achieved. The WQMP instead provides a framework for negotiating mitigation. Additionally, it is not clear if the WQMAB will actually have authority to enforce the WQMP or require DW to conduct mitigation if a problem is identified. This concern was contemplated in Water Right Decision 1643 (D1643, p. 36), which indicated that the WQMP "does not establish a set of enforceable criteria for regulating the operation of the DW Project". Pursuant to CEQA, measures used to mitigate or avoid significant effects on the environment must be fully enforceable through permit conditions, agreements, or other measures (Public Resources Code, § 21081.6(b)).

5-12

DWR is concerned that processes set forth in the WQMP allow the owner of a water treatment plant to waive their protection under the WQMP (p. 5), allowing DW to initiate discharge or diversion from the islands even if the drinking water protection principles are being threatened. This issue was discussed in D1643 (p. 36) and addressed through inclusion of permit terms prohibiting the DW project from causing exceedances of USEPA drinking water MCLs at water treatment plants. It is not clear, however, if these water right permit terms are feasible, given that they cannot be evaluated until models and monitoring are established at a future time. D1643 (p. 3) indicates that DW plans to use water under its existing water rights to support the wildlife habitat on the habitat islands (i.e., Web Tract and Bacon Island) and that the water right applications (A029061, A029063, A030267, and A030269) and petitions relevant to the habitat islands have been canceled. Therefore, it is not readily apparent how water quality restrictions placed on discharges from the habitat islands would be enforced.

5-13

The POU EIR (p.4.2-42) indicates that the WQMP criteria for DOC are more stringent than the thresholds of significance defined in the previous EIR and therefore, project compliance with the WQMP will ensure that DOC impacts are less than significant. However, this statement seems to conflict with language on p. 4-2-37, which indicates that in some cases WQMP criteria are less restrictive than the significance criteria contained in the 2001 FIER. The text refers to the fact that the former significance criteria were expressed as a 0.8 mg/L increase in DOC attributable to the project at Delta export facilities as compared to a 1.0 mg/L increase in TOC allowed pursuant to the WQMP. We note that based on grab sample data collected for Water Years 2005-2007, average TOC/DOC concentrations at Banks were 2.8 and 2.9 mg/L respectively for the months of June through December. Therefore, an allowable increase of 1 mg/L in TOC concentration could amount to up to 34 percent increase in seasonal TOC loading to the SWP. The rationale for relaxing the TOC threshold and the basis for the 1.0 mg/L threshold in WQMP should be explained in the Final POU EIR.

5-14

It appears that the WQMP was crafted to provide protection and recourse for the larger urban water users. The SWP, however, is a source of water for more than 50 small drinking water treatment facilities, including water treatment facilities owned and operated by DWR. According to California Department of Health staff, many of these small facilities either exceed or have difficulty meeting current regulations for disinfection by-products (DBPs) (Carlucci 2010 pers comm). It is not clear if the WQMP will protect small SWP water system users. DW should evaluate and disclose the potential economic, regulatory, and public health impacts to these treatment facilities and their customers, given that the WQMP would allow for an incremental increase in TOC loading to the SWP.

5-15

Unanalyzed Potential Impacts Associated with Nutrients

The POU EIR (p. 4.2-1) indicates that the analysis of effects on water quality described recent changes to the existing environmental conditions and regulatory setting of the project, and that the water quality constituents selected for reassessment or first time assessment was based on new regulation, new information, or WQMP restrictions (p. 4.2-6). A significant amount of new information has been developed regarding the potential impact of nutrients to both drinking water and ecological systems since 2001 when the previous EIR/EIS was completed. Existing environmental conditions are better understood today than in 2001 when the Final Environmental Impact Statement concluded that project operations were not likely to change the supply or concentration of nitrate and phosphate in Delta channels and therefore these constituents were not selected for impact assessment (2001 FEIS, Vol. 1 page 3c-10.). Additionally, the previous analyses did not evaluate ammonia except to say that it oxidized rapidly to nitrate and so concentrations were usually low in Delta channels. Today, nutrients, and ammonium, in particular, have elevated importance in the drinking water, ecosystem and regulatory environment (e.g., CALFED Ammonia/ammonium Workshop, 2009). The POU EIR (pgs. ES-3, ES-4) indicates that updated resource analyses were conducted if new information showed an increase in the severity of impact, however, nutrient impacts were not sufficiently evaluated in the original analysis or in the 2010 POU EIR. Based on the criteria provided in the POU EIR, the impact of the project on nutrient loading to the Delta and the SWP merits further analysis. Specific information and comments pertaining to potential water quality impacts from the DW nutrient discharges follows.

5-16

The POU EIR states that one source of new information used for evaluating water quality was DWR's Report on Jones Tract Flood Water Quality Investigations, 2009 (p. 4.2-7). This document was used by

the DW to assess the impact of the project on dissolved organic carbon (DOC), but the Jones Tract report also contains information on the nutrient dynamics associated with impounded water. For example, concentrations of NH_3 , TKN, Total P, and orthophosphate on Jones Tract were much higher than those detected in receiving water (nitrate and nitrite + nitrate were either similar or lower than receiving water). While variable, concentrations of NH_3 and TKN did not appear to decrease over time. The Jones Tract report points out that NH_3 levels reached concentrations similar to those found downstream of the Sacramento Regional Wastewater Treatment Plant (WWTP), which is the largest WWTP discharge in the Delta.

DW should evaluate whether project nutrient loads are likely to be significantly higher than current loads discharged under the island's farming operations. Given the concerns about current nutrient concentrations in the Delta and SWP&CVP, if it is determined that the project will cause increased nutrient loading, then mitigation should be developed. Likewise, provisions for nutrient control should be considered for incorporation into the WQMP.

New information available on nutrient discharges from a farmed peat island (CA Bay-Delta Authority ERP-02-08, Staten Island Wildlife-Friendly Farming Demonstration Projects) shows that the concentration of NH_3 in pooled Jones Tract waters were similar to those found on Staten Island. Since Webb Tract, Bacon Island, Jones Tract and Staten Island are all treated in the Department's Delta Island Consumptive Use Model as having similar soil make-ups (Jung, December, 2000, MWQI -CR#3), it is reasonable to assume that the nutrient dynamics observed on Staten Island and Jones tract could be used as approximations of what would occur on Webb Tract and Bacon Island. Under a worst case scenario, using the average of the highest NH_3 concentrations detected on Upper and Lower Jones tracts (0.49 mg/L) (similar and higher NH_3 levels were detected in pooled water on Staten Island), and assuming the maximum monthly project discharge of 2,000 cfs (POU EIR, p. 4.2-36), the NH_3 load discharged from the project would be approximately 2,300 kg/day. It is unclear whether 2,000 cfs or 4,000 cfs would be the maximum discharge rate for the project (see page 3-5), but if discharge was 4,000 cfs, NH_3 loads would double to about 4,600 kg/day. The highest daily load discharged off of Staten Island was 67 kg/day. Based on these projections, project operations could have the potential to increase NH_3 loads to receiving waters by a factor of 34 to 64 times over current farming operations.

5-16
Cont

For illustrative purposes, we compared the project's potential maximum NH_3 loading rates to the loading rates of the largest discharger of NH_3 in the Delta, the Sacramento Regional County Sanitation District (SRCSD) Wastewater Treatment Plant. SRCSD's current permitted discharge capacity is 181 mgd (average dry weather flow) and their current effluent flows average 141 mgd, while the plant's median ammonia level is 24 mg/L (Central Valley Regional Water Quality Control Board, NPDES Permit Renewal Issues Paper, 12/14/09). At the current average flow of 141 mgd, ammonium loads would be 12,801 kg/day. At permitted capacity, ammonium loads would be 16,443 kg/day. The potential ammonium loads from project discharges at 2,000 cfs represents approximately 18% of the average ammonium load of the largest discharger to the Delta. At a discharge rate of 4,000 cfs, the ammonium load from the project would be equal to about 36% of SRCSD's daily average ammonium load. If the project is approved, it would potentially be one of the largest dischargers of ammonium to the Delta ecosystem. Additionally, the Central Valley Regional Water Quality Control Board is in the process of revising the SRCSDs NPDES permit. SRCSD is proposing to increase its permitted discharge from 181 to 218 mgd which could result in significant additional nutrient loading to the Delta and SWP. This is important because the SRCSD expansion was not one of the projects considered in the cumulative impact analysis (POU EIR, pgs. 5-2, 5-3). Furthermore, DW discharges are much closer to SWP export facilities than Sacramento County Regional Sanitation District's outfall.

From a drinking water perspective, NH_3 is a required precursor for forming nitrosamine disinfection by products (DBP). Nitrosamine DBPs are more carcinogenic than currently regulated DBPs, and are the most likely DBP to be regulated in drinking water by the EPA within the next 5 years (Bruce Macler, EPA, Region 9, pers comm. April 2010). An increase in NH_3 from DW has the potential to increase Nitrosamine DBP formation at SWP water treatment plants.

Unanalyzed Potential Impacts Associated with Drinking Water Taste and Odor

DW should also evaluate the potential effects associated with the changes in timing of nutrient loading and the potential for project discharges to increase the levels of taste and odor compounds present in drinking water supplies. As documented in the Staten Demonstration project, nitrate, ammonium, and TKN loading from a farmed Delta island were lowest in the summer and fall. Due to farming cycles, it is expected that similar loading patterns would be observed for most farmed Delta islands. Since the project proposes to discharge potentially high loads of nutrients in the summer and fall, when nutrient loading from the predominant land-use in the Delta is low, project discharges would likely increase nutrient concentrations at the Delta export locations, which in turn could lead to more algal production and taste and odor problems.

Algal blooms and aquatic plant growth already require chemical treatment and/or physical removal at certain SWP facilities, including Clifton Court, trash racks along the California Aqueduct, the South Bay Aqueduct, the Coastal Branch, and Southern California reservoirs. Copper sulfate is commonly used to treat algal blooms in the SWP, but this can lead to unintended adverse effects for drinking water treatment. For example, die off of treated algae can cause taste and odor problems and filter clogging. Additionally, the cost of additional treatment is passed on to DWR and the SWP&CVP contractors.

Recent research suggests that phytoplankton community assemblages can shift depending on whether the species preferentially uses ammonium (Glibert, 2010). Blue-green algae use ammonium preferentially. DW should therefore evaluate the potential for increased taste and odor associated with blue-green algal blooms from increased ammonium and other nutrient loading during periods of project discharge. With respect to nutrients and algal production, the Jones Tract Report documents that the State Water Project and Jones Tract received extensive media attention because of taste and odor problems in drinking water.

Geosmin and 2-methylisoborneol (MIB) produce earthy and musty taste and odor in drinking water. Geosmin is detectable by humans at less than 10 ng/L, and MIB is detectable by humans at 3 ng/L, with drinking water customer complaints rising steeply with increasing concentration. For example, in February 2009, a taste and odor event in the source waters of the SWP's North Bay Aqueduct forced multiple water suppliers to switch to alternate sources and produced hundreds of complaints. In the case of Jones Tract, DWR identified the blue-green algae, *Planktothrix peromata* as one of the main producers of taste and odor compounds. *Planktothrix* produces the taste and odor compound MIB at much higher rates than any other species observed in Southern California reservoirs, requiring repeated and costly algal prevention measures for the utility. Based on modeling of DOC, the Jones Tract Report concluded that taste and odor problems, due to algae at Banks, occurred from the high nutrient water transported out of Jones Tract. *Planktothrix* was also transported in the aqueduct to downstream reservoirs. This species of taste and odor algae had never been detected in a Southern California State Water Project Reservoir by Metropolitan Water District prior to the pump off of Jones Tract water (MWD, Member Agency Water Quality and Supply Webinair, 2009). Additionally, samples from within the flooded Jones Tract had geosmin concentrations as high as 30 ng/L, and MIB concentrations greater than 1000 ng/L in July 2004. Concentrations remained elevated through October 2004. During the same period, concentrations of taste and odor compounds increased at routine sampling sites at Clifton Court Forebay, Banks Pumping Plant, and the South Bay Aqueduct. This information strongly suggests that the project could exacerbate taste and odor concerns in the SWP; however, these issues were not evaluated and disclosed in the POU EIR or in previous environmental documents for the project. An evaluation should be conducted, the results disclosed, and mitigation measures for negative impacts to the SWP included in the Final POU EIR.

Bacteria Concerns

DW has never assessed the impacts to drinking water and public health associated with bacteria. Although bacterial levels fell in Jones Tract, once initial septic tank waste and decayed animal material was metabolized, spikes in fecal coliform levels have been found in reservoirs around the country due to large numbers of waterfowl using systems that are predator free. The water quality objective for contact recreation calls for a 30-day average of 200 MPN/100 mL with no more than 10% of the measurement

above 400 MPN/100mL for fecal coliform. The SWRCB is considering adopting *E. coli* freshwater monitoring objectives. If so, the median of 5 samples over a 30 day period cannot exceed 126 MPN/100 mL. At a minimum, fecal coliform and *E. coli* monitoring should be included in the WQMP, and if warranted, a management plan to discourage waterfowl needs to be implemented. Increased bacteria monitoring is also warranted based on the recreational uses near the island.

5-1
Cont

Flood Control and Levee Stability – Section 4.3

Impacts from Seepage Levels and Seismic Events

The POU EIR addresses potential environmental effects associated with the diversion and storage of water by the DW Project. To better understand the POU EIR, we have also reviewed the report prepared by Hultgren-Tillis Engineers, titled as "Geotechnical Evaluation, Seismically Repairable Levee, Webb Tract", dated December 30, 2009.

The review of the above mentioned reports indicate that the proposed design for the Reservoir Island calls for the following key features:

- Protect the slough side slope (2:1) with rip-rap and in over-steepened areas a waterside notch to create a bench and flatter slope
- Widened the crest to 45 feet
- The landside slope will be 3:1 on upper end and 10:1 on lower end
- Placement of a core trench through the levee prism

5-19

We believe that the proposed design will improve the slope stability and reduce the through-seepage for static loading conditions. The project has the burden to prove that proposed Reservoir Islands do not adversely affect the groundwater regime of the neighboring islands. In principle, we believe that the insertion of the core trench will address the through-seepage issue. However, a well planned seepage monitoring program is vital to fully address seepage issues that may adversely impact groundwater levels and should be added to the Final POU EIR.

Although the reports address the seismic impacts on the project through the concept of seismically repairable levees, seismic performance is not adequately addressed to demonstrate that the Reservoir Island levees would not breach under a considered design seismic event. Seismic-induced deformation (both inertial and liquefaction-induced) is a key indicator of the seismic stability of the levee, however, the reports lack information related to the seismic deformation. Specifically, the reports lack information regarding seismic design criteria used for the analyses including seismic design level, acceptable performance during a design event, and an emergency repair plan. If an uncontrolled release of reservoir water is a reasonable possibility due to a seismic event, then impacts on neighboring levees due to increases in hydraulic head and/or scour should be evaluated, disclosed and mitigation measures included in the Final POU EIR.

5-20

Vegetation and Wetlands – Section 4.6

The Delta Wetlands Project provides compensation for wetland and wildlife effects of the water storage operations on the reservoir islands by implementing a Habitat Management Plan on two habitat islands (Bouldin Island and Holland Tract). The habitat creation proposed would provide positive benefits for enhancing Delta habitats including AB360 habitat types, riparian, and freshwater wetlands. The environmental review for Delta Wetlands has undergone several iterations, and because the "habitat creation" plans were not thoroughly discussed in the most recent version, it was very difficult to review the habitat elements of the proposal. However, DWR has certain concerns that need to be clearly addressed:

5-21

- Habitat creation plans should be thoroughly vetted with an expert panel including scientists recognized for their work in wetland restoration and/or levee stability.
- Though recent versions of the EIR make statements that suggest the habitat island plans have not changed from earlier versions, the current rendition of the plan appears to provide less acreage than earlier versions. The habitat maps provided in the 2010 version of the EIR indicate that some of the earlier habitat areas may have been replaced with agriculture and/or development. This is not clear from the narrative. The reasons for these changes, if they exist, should be made explicit and evaluated using the California Environmental Quality Act (CEQA) checklist.
- Because the wetland delineation has expired, the Project applicant is consulting with the US Army Corps of Engineers regarding necessary updates to the wetland delineation and plans to conduct field studies necessary to re-verify the wetland delineation. This process must be completed before project impacts to wetlands can be evaluated as required under CEQA.
- Proposed habitat designs for created habitats should follow natural landscape contours and incorporate subsidence reversal techniques to minimize inundation due to accidental breaches in the long-term.
- Finally, the proposed project should include a long term management plan for habitat and levee maintenance.

5-21
Cont

Climate Change - Section 4.14

Outdated Climate Change Projections

To the extent required by CEQA Guidelines Section 15126.2, all significant state projects, including infrastructure projects, must consider the potential impacts of locating such projects in areas susceptible to hazards resulting from climate change. (CA Climate Adaptation Strategy 2009)

Cayan et al. 2006b citation is out of date. The 2009 Scenarios Report predicted 12 – 18 inches by 2050 and 21 - 55 inches by 2100.

Based upon this section, we cannot determine if this project would adversely affect the SWP&CVP due to effects of sea level rise and winter storm surge.

Neither Chapter 4.3 Flood Control and Levee Stability nor 4.14 Climate Change adequately address the potential environmental impact of a catastrophic failure of the Project's levees.

5-22

Climate change is expected to increase sea level as mentioned in the document. However several other impacts are also expected as a result of climate change. The additional impacts noted below are not adequately addressed in the document.

- A likely increase in the frequency and severity of storms driven by the atmospheric river or "pineapple express" phenomenon-the meteorological phenomenon responsible for all of the largest floods in Central Valley history (Dettinger, Hidalgo, & Tapash Das, 2009).
- Higher 3-day peak runoff patterns over the past 50 years as compared to conditions prior to 1955 (DWR, Progress on Incorporating Climate Change into Planning and Managing California's Water Resources, 2006).
- Significant increases in the percentage of precipitation that falls as rain instead of snow during winter storms in the Sierra Nevada (DWR, Progress on Incorporating Climate Change into Planning and Managing California's Water Resources, 2006).
- Winter snowpack in the Sierra Nevada is now smaller and is melting earlier than historically.
- Higher sea levels will continue to increase the stress on Delta levees, increasing the chances of failure (Cayan D. M., 2008).

- Higher sea levels will increase the possibilities of flooding at the mouths of rivers as high sea level stands (driven by tides, storm surges, El Niño influences and climate change driven sea level rise) coincide with high fresh water flows (Dettinger, Hidalgo, & Tapash Das, 2009).

Additionally, the planned operation of the project entails raising and lowering of the water levels in water supply storage islands, which are protected by earthen levees. This operation could result in rapidly changing differential head conditions between the river/slough side of levees and island/reservoir side of levees. There is no discussion of the ability of the levees to withstand these conditions.

5-22
Cont

Individually or synergistically these impacts have the potential to increase the stress on the Proposed Project's levees increasing the potential for a catastrophic failure that could have wide ranging impacts to water quality, water supply, and habitat throughout the Delta. These issues must be adequately investigated, analyzed, disclosed, and mitigated in order to make a determination of environmental significance in the Final POU EIR.

Cumulative Impacts – Chapter 5

Bay Delta Conservation Plan (BDCP)

Page 5-6 - The tunnel / all-tunnel option should be altered to reflect the preferred nomenclature of the "pipeline option." Delta Corridors is now "Separate Corridors Option."

5-23

Page 5-6, 5-7 - The BDCP section should also include a link to the BDCP website (<http://baydeltaconservationplan.com/default.aspx>).

5-24

In light of BDCP's restoration and conservation measures, which include the creation of intertidal habitat and potential North Delta diversions, consider analyzing the DW Project's impacts and cumulative impacts to tidal prism (intertidal habitat and wetland habitat).

5-25

Page 5-58 Climate change: Depending on the land cover (e.g., wetland, intertidal) created in the habitat management plan there will be GHG emissions (e.g., CO₂ and CH₃) that should be documented and included in the analysis. The Final POU EIR should address potential increases in GHG emissions.

5-26

ES-17; Impact UT-6:

Greater Sandhill Cranes are present on all islands (4.7-23); Mitigation measure for UT-MM-2 and UT-MM-10 will create a power line collision risk for a California fully protected species. Mitigation measure should consider placing power lines below and alongside levee to reduce collision risk.

5-27

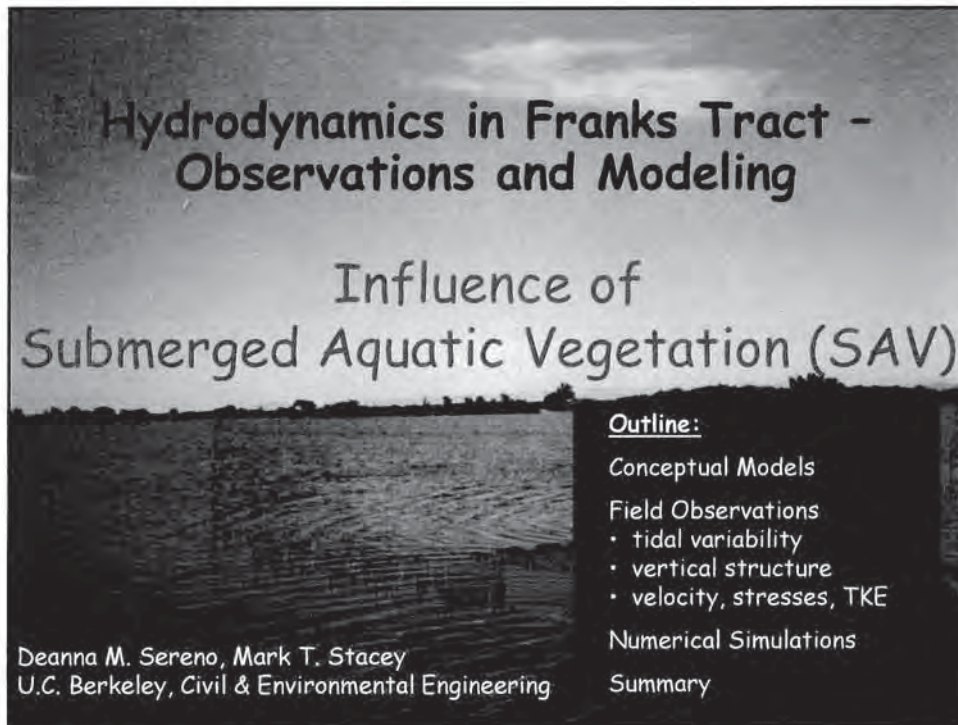
Hydrodynamics in Franks Tract - Observations and Modeling

Influence of Submerged Aquatic Vegetation (SAV)

Outline:

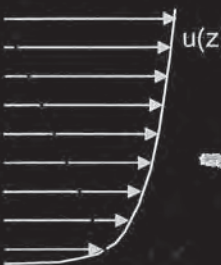
- Conceptual Models
- Field Observations
 - tidal variability
 - vertical structure
 - velocity, stresses, TKE
- Numerical Simulations
- Summary

Deanna M. Sereno, Mark T. Stacey
U.C. Berkeley, Civil & Environmental Engineering



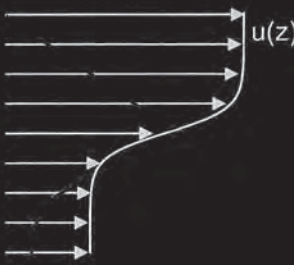
Conceptual Models

Traditional – Boundary Layer



Mixing Layer Analogy

Raupach, Finnigan and Brunet (1996)
Grisalberti and Nepf (2002)



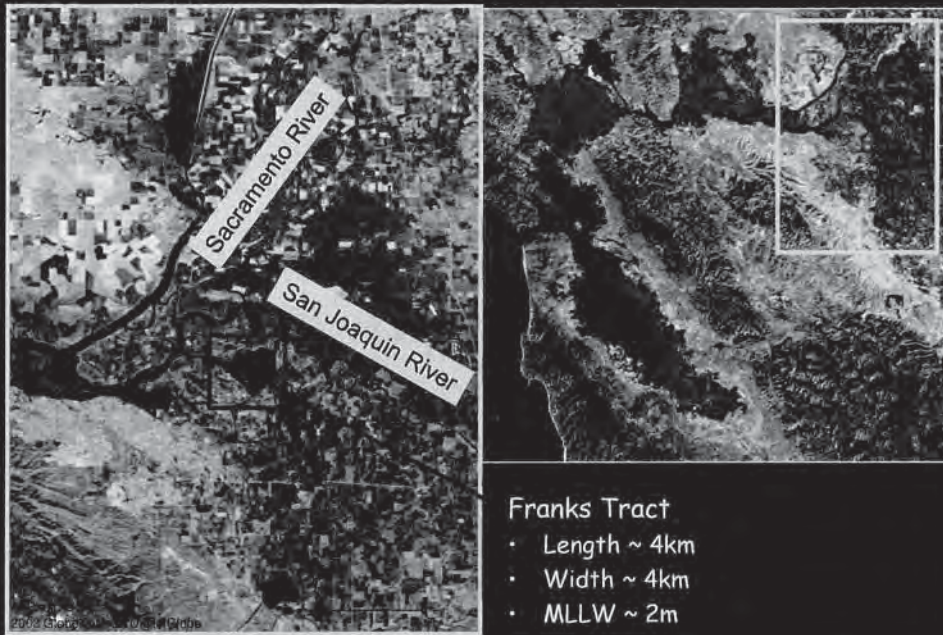
velocity

Water balance - models are equivalent

Horizontal/Lateral Gradients - vertical structure important

- Near bed >> sediment resuspension
- Near top of SAV canopy >> mixing

Location



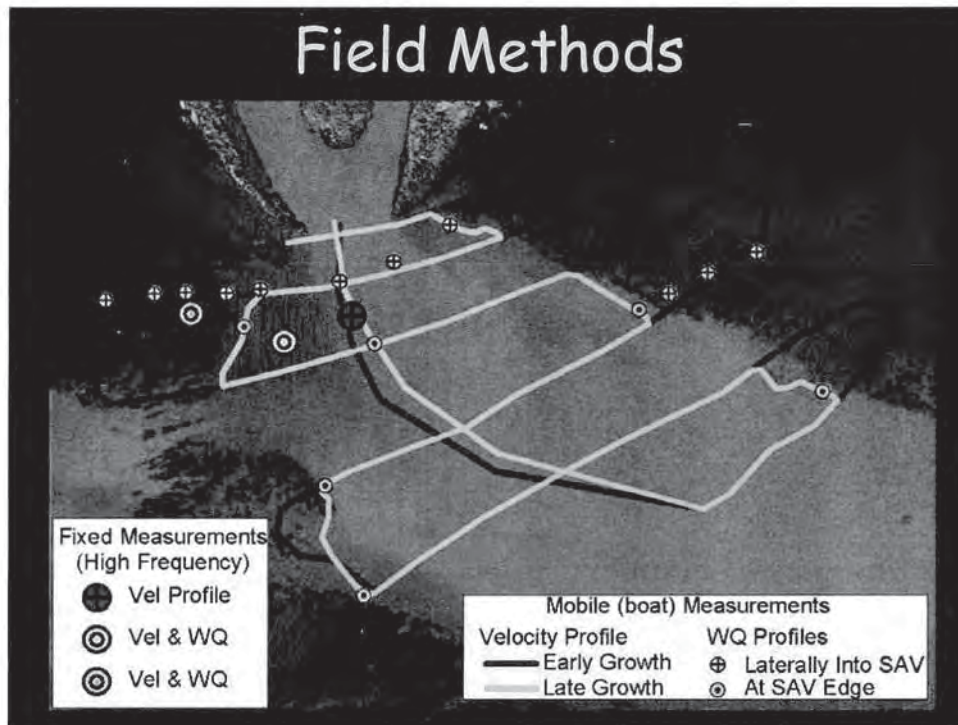
Location

Franks Tract (FT)

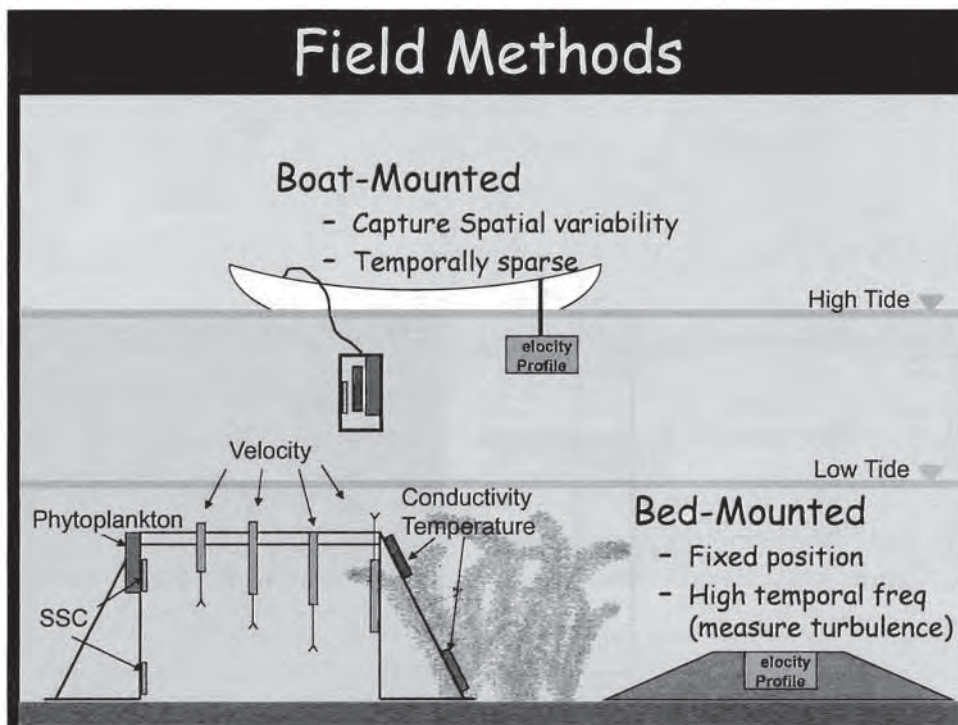
- Numerous Connections to surrounding channels
- SAV
 - "channelizes" FT
 - Density and height vary significantly, spatially and seasonally
- Residence Time
 - No SAV in lake (uniform drag)
 - Models: $T \sim \text{week}$
 - SAV distribution
 - Drifter: $T_{OW} \sim 6\text{hrs}$
 - $T_{SAV} \gg T_{OW}$



Field Methods



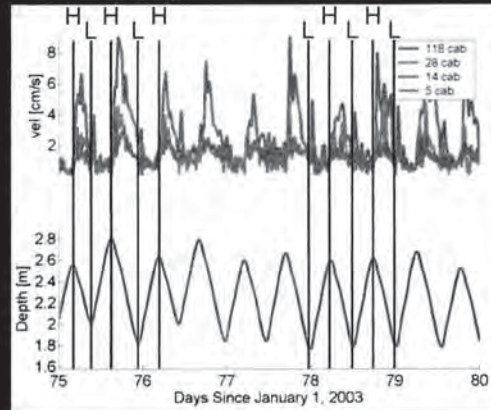
Field Methods



Field Data - Time Series

Tidal Variability

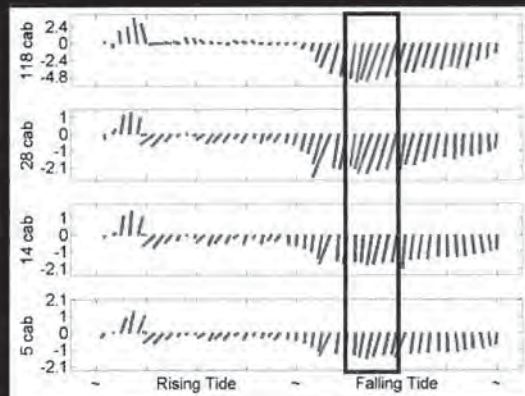
- Phasing
 - ~ 90deg phase difference between velocity magnitude and tidal stage
 - High/Low Tide ~ slack
 - Rising Tide = Flooding
 - Falling Tide = Ebbing
- Flood/Ebb Asymmetry
- Aggregation of Data into the "Typical Tide"



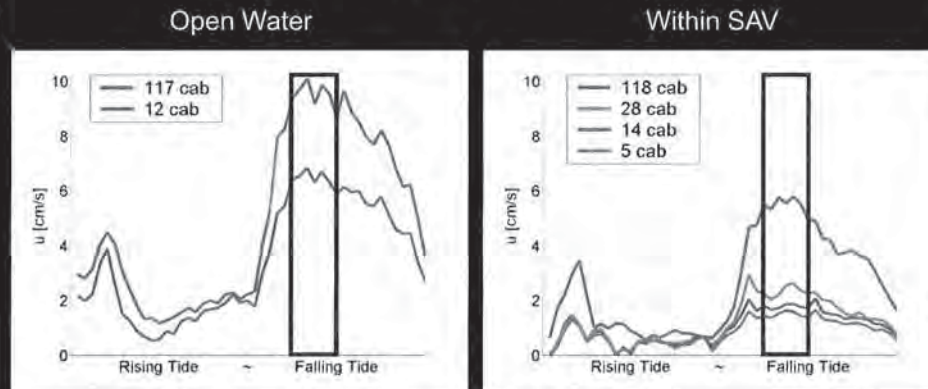
Field Data - Typical Tide

Velocity Vectors

Flow fields at multiple heights within the SAV

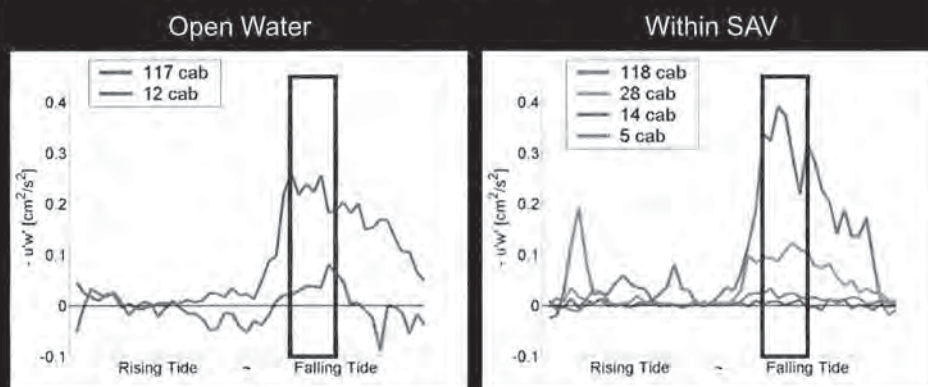


Field Data - Typical Tide Velocity



- Tidal Asymmetries similar at both stations
- Velocities within the SAV are reduced during all tidal phases

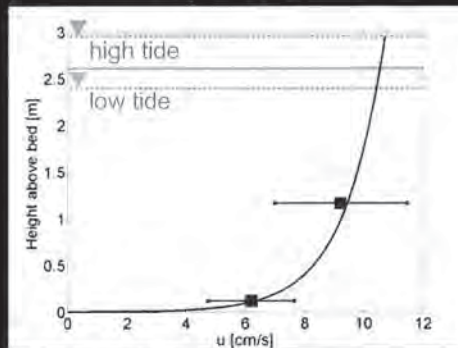
Field Data - Typical Tide Reynolds Stress



- Bottom Sensor (ebb) dominated by sweeps/ejections
- Bottom Sensors show low stress (limited resuspension)
- Stress increases above bed (consistent with ML analogy)

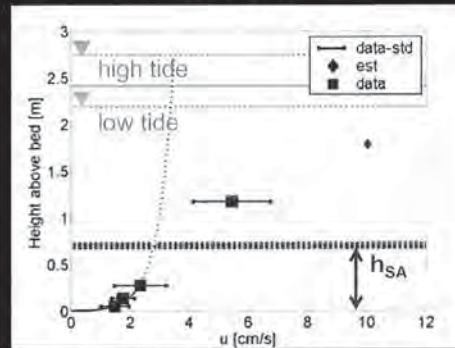
Field Data - Vertical Structure Velocity During Ebb OW --> SAV

Open Water



- Assume log profiles
- Mass Conservation as Transported into SAV with 50% diversion/storage factor

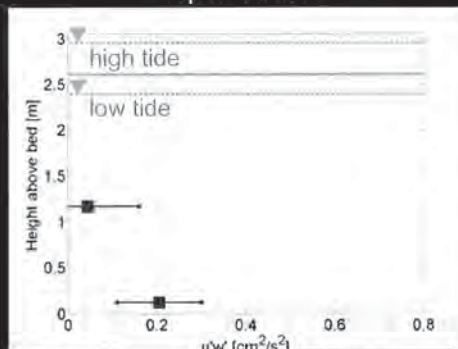
Within SAV



- $u(bot)_{SAV} \sim 1/3 u(bot)_{OW}$
- Data above SAV canopy and estimated value of over-canopy flow indicate strong vel shear

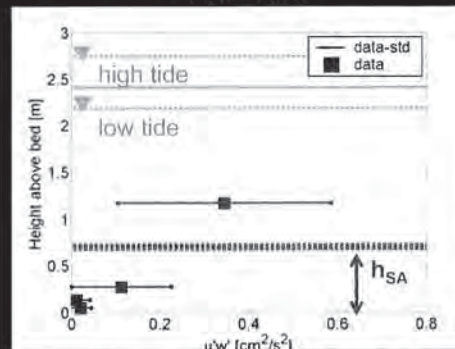
Field Data - Vertical Structure Stress During Ebb OW --> SAV

Open Water



- High Stress near bed; decreasing towards surface

Within SAV



- $u'w'(bot)_{SAV} \sim 1/10 u'w'(bot)_{OW}$
limited sediment resuspension
- High stress mid-water column due to the presence of SAV

Model - Vertical Structure

Water Column Model (1D)

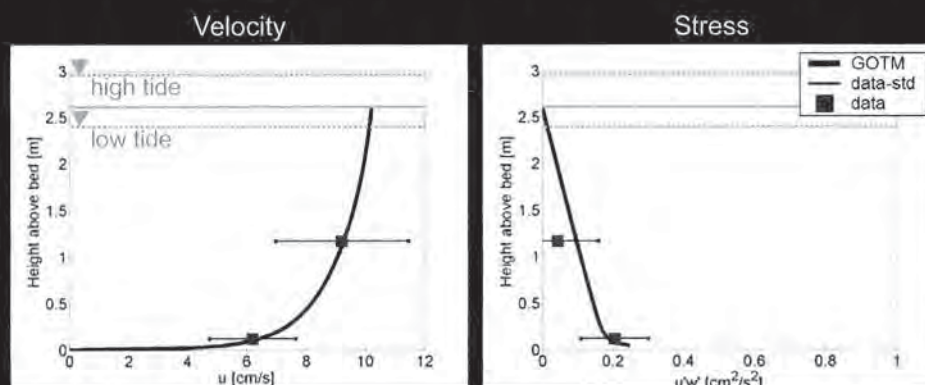
General Ocean Turbulence Model (GOTM)

www.gotm.net

- Traditional BBL Approach
 - Method 1: Increase bed drag
 - Method 2: Raise bed (no flow below false bed)
- Water Column Drag
 - Method 3: Vertically variable drag coefficient

Model - Traditional BBL

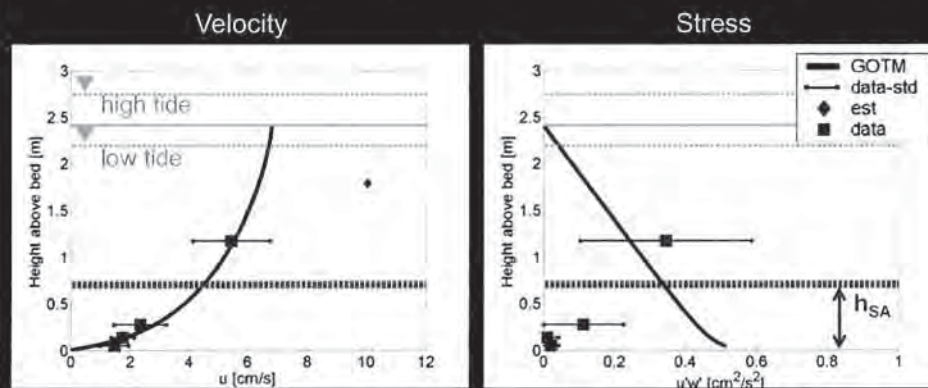
Field Data - Model Comparison: Open Water



- Logarithmic profile; characteristic of open channel flow (OCF)
- Data & Model indicate highest stresses at the bed (OCF)
- Fit is good; model is overestimating, but w/i error

Model - Traditional BBL

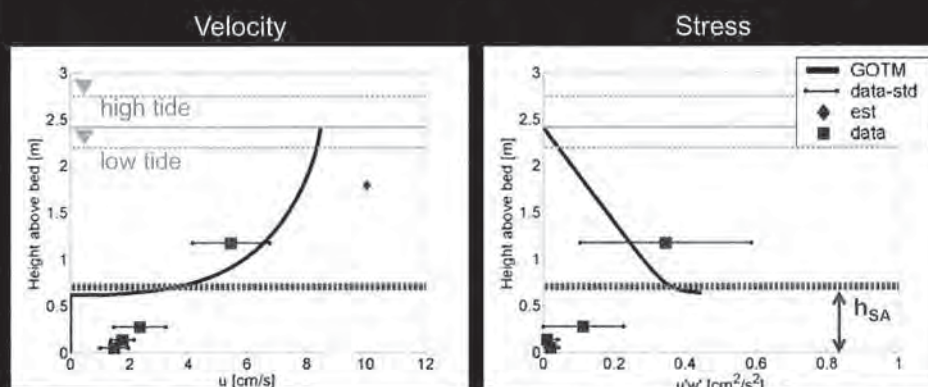
Field Data - Model Comparison: SAV - Method 1



- Calibration to conserve mass; depth-average velocity
- Stress is overestimated at bed
- Not capturing physics of transport

Model - Traditional BBL

Field Data - Model Comparison: SAV - Method 2



- Calibration to conserve mass; depth-average velocity
- "Stagnant" Layer
- Stress within water column 'fit'
- Model overhead - exchange between 2 layers

Vertical Structure

Water Column Drag

www.gotm.net

vertically variable drag coefficient

- Mean flow (simplified momentum equation):

$$\rho g \left(\frac{d\eta}{dx} + D_z \right) u^2 = - \rho g \frac{d\eta}{dx} - \rho g \frac{d\eta}{dx}$$

- Turbulence (additional production):

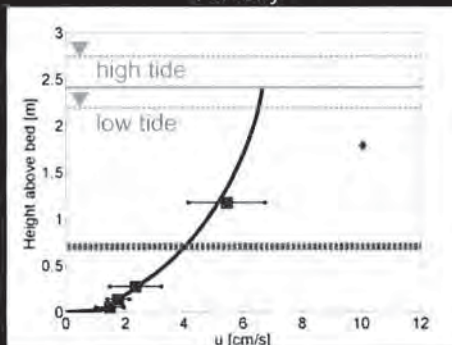
$$\rho g \left(\frac{d\eta}{dx} + D_z \right) u^2 = - \rho g \frac{d\eta}{dx} - \rho g \frac{d\eta}{dx}$$

$$\lambda \rho u^2 / (2 \pi \omega)$$

Model - Water Column Drag

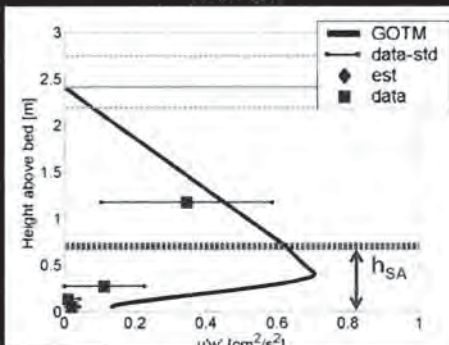
Field Data - Model Comparison: SAV - Method 3

Velocity



- Model fit is good to data
- Estimated value may be an overestimate (>50% diversion from OW)

Stress



- Data & Model indicate increase in Stress above bed
- Consistent with data and ML theory

Model Summary

Model Method	Increase bed roughness	Raise bed elevation	Add Drag Water Column
Advantages	implementation		performance
Disadvantages	performance	separate transport model	implementation
CALIBRATION & VARIABILITY of SAV			
Flow Rate	✓	✓	✓
$u(z)$	no	no	yes
$u'w'(z)$	+++ bed	0 at bed	+ bed

Summary

- Field Data - Typical Tide (site specific)
 - In both flood and ebb
 - Tidal structure/asymmetry is consistent b/w OW and SAV sites (100m apart)
 - Ebb comparison (OW flowing into SAV)
 - SAV velocity ~ 15-50% OW velocity
 - SAV site has
 - ♦ strong velocity shear b/w bottom sensors and top sensor
 - ♦ Low near bed stress; High stress up in the water column
- Traditional View (Perturbed BBL) limited
 - Underestimates mixing near top of canopy
 - Overestimates stresses near bed
- Water Column Drag
 - Simulates mean velocity structure well; overestimates stresses (slightly)
 - $C_d(z)$ or even h_{SAV} is seldom known or varies seasonally

Acknowledgements

Funding provided by CALFED.

USGS - Sacramento

Jon Burau, Jay Cuetara, Jon Yokimizo, Curt Battenfeld, Jim DeRose,
Cathy Ruhl, Mike Simpson, Jim George

USGS - Menlo Park

Jim Cloern, Lisa Lucas, Tara Schraga, Cary Lopez, Francis Parchaso

UC Berkeley

Mark Stacey, Bill Dietrich, Seungjin Baek, Jon Fram, Maureen Martin, David Ralston,
Stefan Talke, Tim Banyai

UC Davis

Bill Fleenor

USDA - ARS Weed Science Program

Lars Anderson

CA DWR

Lenny Grimaldi

Using Hydrodynamics to Examine Differences in Flooded Island Environments

Lessons Learned, Questions Raised

Deanna Sereno
U.C. Berkeley, Civil & Environmental Engineering

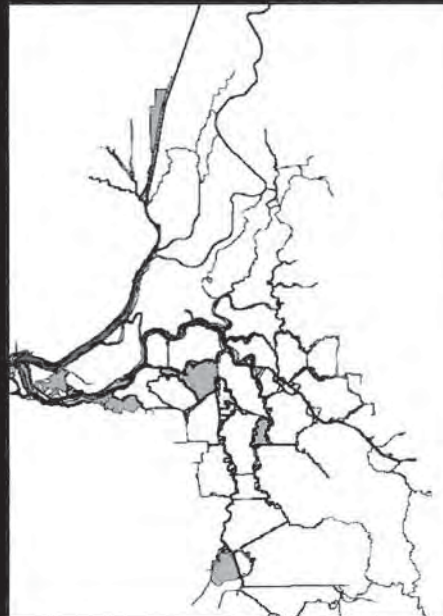
With ...

M.T. Stacey, S. Baek
U.C. Berkeley, Civil & Environmental Engineering

J.R. Burau, J.I. Cuetara, C.A. Ruhl, R. L. Dinehart, and J.E. George
U.S. Geological Survey, California District

Motivation

Why Flooded Islands ?



Motivation

Why Flooded Islands ?

- CALFED ERP calls to create mixture of SWH, some acreage possibly by flooding islands
- Examine existing flooded islands

Which Flooded Islands?

- Compare/Contrast Characteristics

Mildred Island (MI)

Length = 3 km
Width = 1 km
Depth = 5 m



Franks Tract (FT)

Length = 4 km
Width = 4 km
Depth = 2 m

Motivation

Why Flooded Islands ?

- CALFED ERP calls to create mixture of SWH, some acreage possibly by flooding islands
- Examine existing flooded islands

Which Flooded Islands?

- Compare/Contrast Characteristics
- Previous Studies

Mildred Island (MI)

Length = 3 km
Width = 1 km
Depth = 5 m



≠



Franks Tract (FT)

Length = 4 km
Width = 4 km
Depth = 2 m

Lucas, et al, 2002

Hydrodynamics and Ecosystem Dynamics

Delta-Scale hydrodynamics
set the picture

Transport between SWH and
Channels determines
residence or flushing
times

Exchange between sub-
regions or sub-habitats
within SWH

Mixing sets detailed
distributions of scalars



Hydrodynamics and Ecosystem Dynamics

Delta-Scale hydrodynamics
set the picture

Transport between SWH and
Channels determines
residence or flushing
times

Exchange between sub-
regions or sub-habitats
within SWH

Mixing sets detailed
distributions of scalars



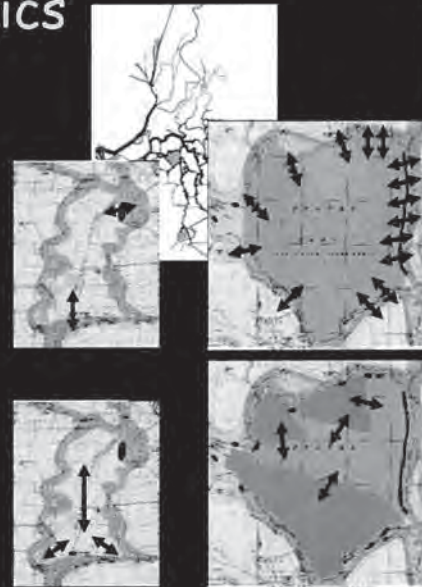
Hydrodynamics and Ecosystem Dynamics

Delta-Scale hydrodynamics
set the picture

Transport between SWH and
Channels determines
residence or flushing
times

Exchange between sub-
regions or sub-habitats
within SWH

Mixing sets detailed
distributions of scalars



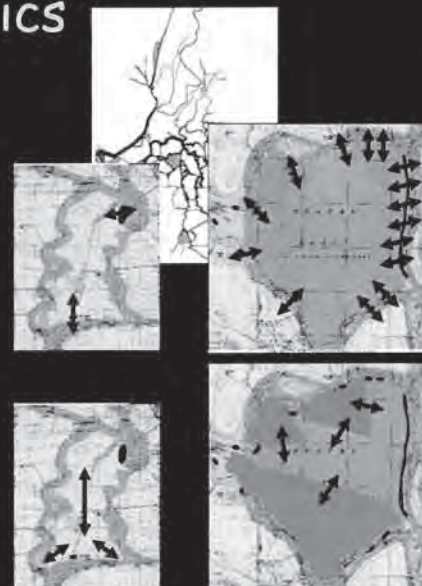
Hydrodynamics and Ecosystem Dynamics

Delta-Scale hydrodynamics
set the picture

Transport between SWH and
Channels determines
residence or flushing
times

Exchange between sub-
regions or sub-habitats
within SWH

Mixing sets detailed
distributions of scalars



Field Methods

Insitu Instrumentation

- Long-term (USGS Sac and USGS Menlo Park)



Chl Fluorometer



ADCP



CTD



Meteorological Station

Field Methods

Insitu Instrumentation

- Long-term



All instruments survived, data good!

Jon Burau, Jay Cuetera,
Jon Yokomizo, Curt Battenfeld

Field Methods

Insitu Instrumentation

- Long-term
- Short-term, high frequency BBL (UC Berkeley)
 - 2-4 ADVs (velocity, pressure)
 - 2 CTs (conductivity, temperature)
 - 2-3 OBSs (suspended particles)



Field Methods

Insitu Instrumentation

- Long-term
- Short-term, high frequency BBL

Synoptic Studies

- Flow Mapping (USGS Sac and UC Berkeley)
- Drifter Releases (USGS Sac)



Hydrodynamics and Ecosystem Dynamics

Delta-Scale hydrodynamics
set the picture

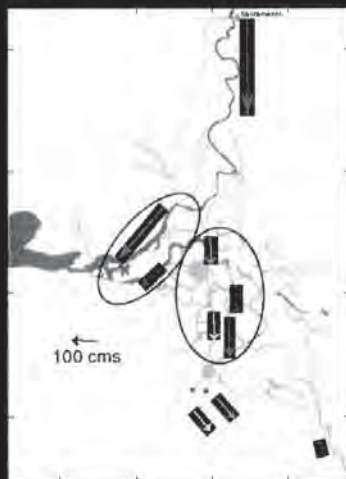
Transport between SWH and
Channels determines
residence or flushing
times

Exchange between sub-
regions or sub-habitats
within SWH

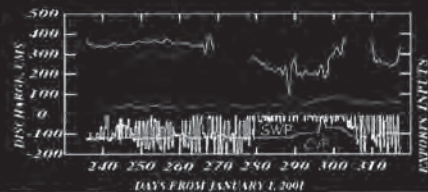
Mixing sets detailed
distributions of scalars



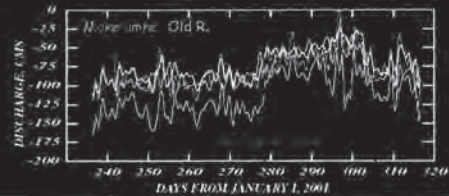
Delta-wide Net Flow



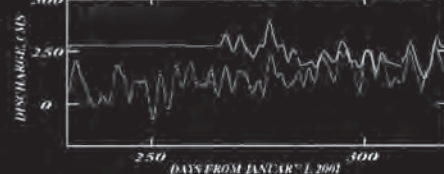
Inputs /
Exports



Central
Delta



To Bay



Courtesy Jon Burau

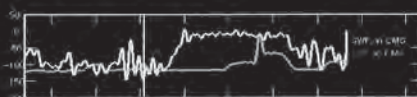
Delta-wide Net Flow

Delta Flows / Export Pumps

- (1) Mildred is strongly influenced by pumping
- (2) Spring/neap response in western Delta
- (3) Pumps do not pull water directly from the Mokelumne



Sep. 27, 2001 at 08:14 PM

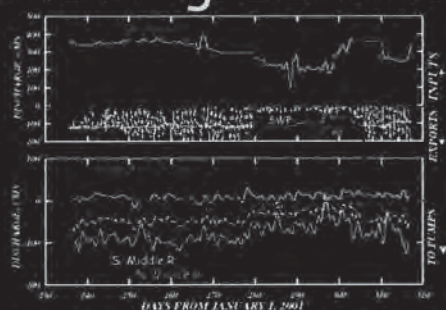


Courtesy Jon Burau

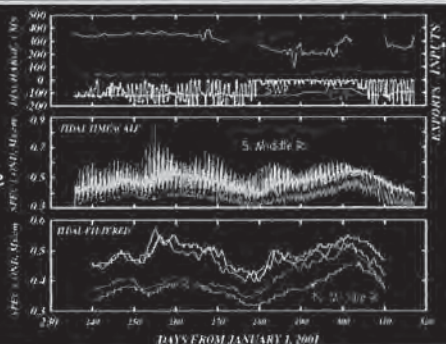
Net Flow and SC in MI Neighborhood



Net flows



Specific conductance

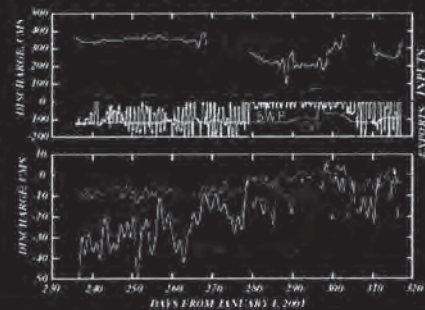


Courtesy Jon Burau

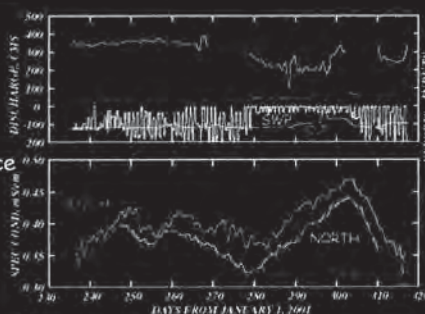
Net Flow and SC within MI



Net flows



Specific conductance



Courtesy Jon Burau

Delta-Scale Summary

Lessons Learned

- Central Delta is strongly affected by pumps
- MI neighborhood and interior are strongly influenced by regional setting
- MI is leaky
- SWH Design Issues
 - should consider regional water quality issues
 - unattended levees may deteriorate → leaky habitat

Questions Raised

- Secondary estimate of residence/flushing time from SC? [possible analysis with existing data]

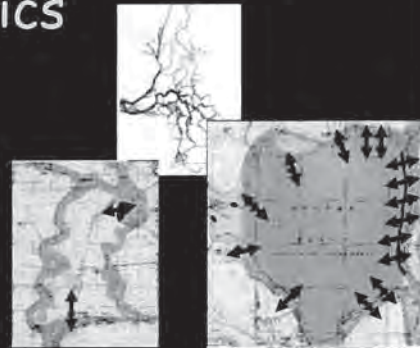
Hydrodynamics and Ecosystem Dynamics

Delta-Scale hydrodynamics set the picture

Transport between SWH and Channels determines residence or flushing times

Exchange between sub-regions or sub-habitats within SWH

Mixing sets detailed distributions of scalars



SWH $\leftrightarrow$ Channel Exchange

Classic Tidal Asymmetry

- High momentum, fast velocity jet of water entering lake
- Slower moving water exiting lake, approaches from all directions
- If constituent concentration varies spatially $\rightarrow$ net exchange



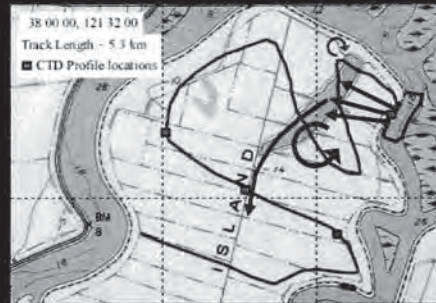
Jet Dynamics

- Width of jet expands as it enters the lake
- Vortices form at jet edges
 - entrain "interior" fluid
 - mixes jet water with interior water

SWH $\leftrightarrow$ Channel Exchange

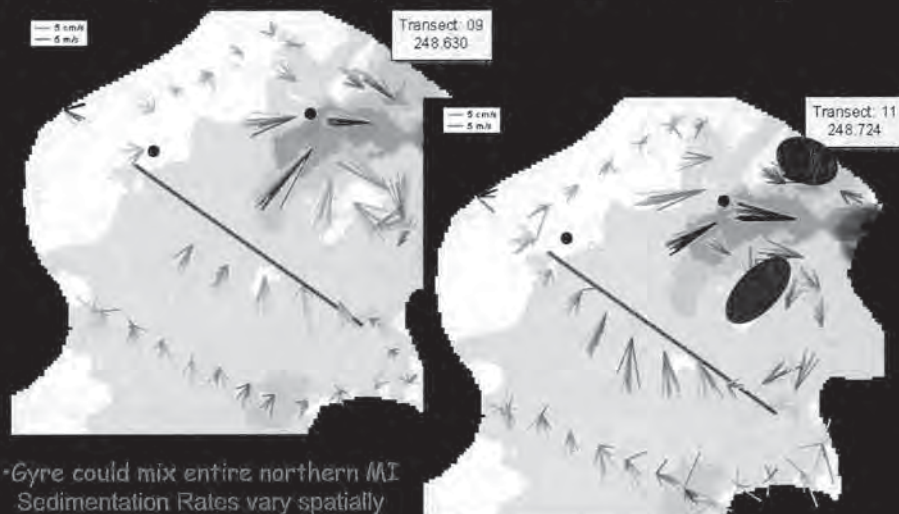
Geometry/Bathymetry will set level of Mixing

- Flow enters opening, perpendicular to opening
- Further inside lake, flow direction is aligned with barotropic gradient
- Curved flow lines impact recirculation gyres
- Impact of gyres
 - Increase mixing
 - Increase sedimentation



SWH $\leftrightarrow$ Channel Exchange

Geometry/Bathymetry will set level of Mixing



SWH $\leftrightarrow$ Channel Exchange

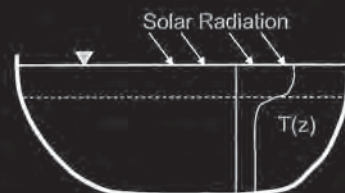
Mixing at Opening - Implications for models

- 1D and some 2D Models
Assume SWH is Completely Mixed
 - N MI opening is very effective at mixing
 - ONLY mixes NORTHERN MI, < 1/3 volume of MI
- 2D and 3D Models w/SWH bathymetry
 - Capture the spatial/temporal variability in mixing
 - Are other factors important?

SWH $\leftrightarrow$ Channel Exchange

What about other factors?

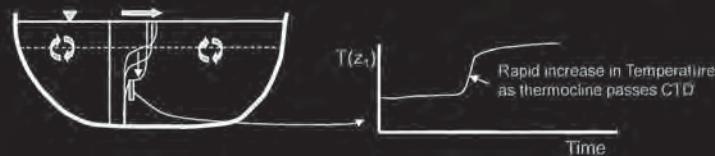
- Tides, river input, bathymetry (standard in models)
- Solar Heating
 - During Day, heating creates thermal stratification; reduces mixing
 - During Night, surface cools reducing stratification



SWH $\leftrightarrow$ Channel Exchange

What about other factors?

- Wind
 - Deepen mixed layer, mixing interface past instruments



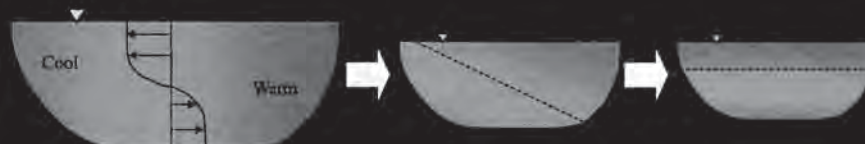
- Tilt interface, drive upwelling and downwelling



SWH $\leftrightarrow$ Channel Exchange

What about other factors?

- Wind + Solar Heating $\rightarrow$ Lateral Temp Gradient



Lateral density gradients drive lateral exchanges

- LOW Temp $\gg$ HIGH Temp on bottom, reversal on surface
- Relaxes horizontal gradients into vertical gradients

Density driven flows will oppose upwelling motions

Lateral density gradients maintained by:

- Vertical Mixing
- Horizontal Transport
- Differential heating/cooling

SWH $\leftrightarrow$ Channel Exchange

What about other factors?

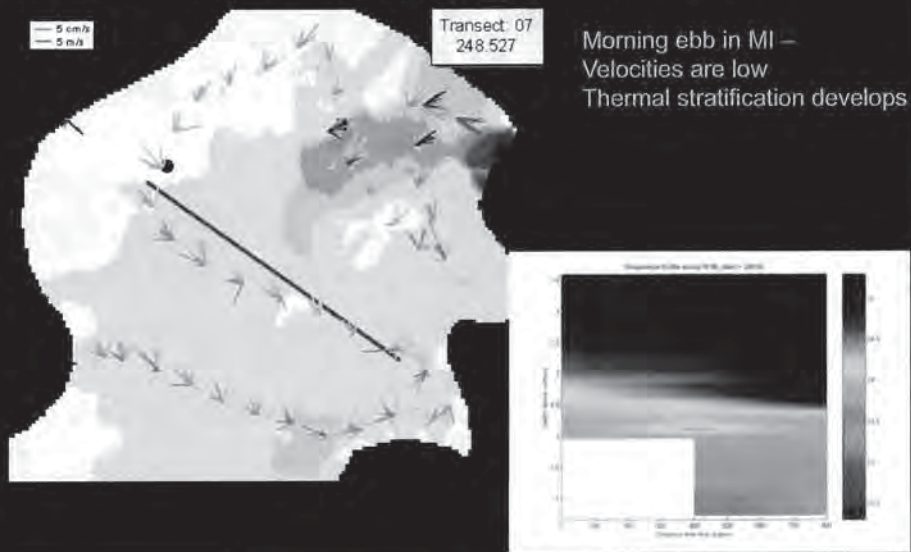
- Tides, river input, bathymetry (standard in models)
- Solar Heating
- Wind
- Submerged Aquatic Vegetation

It is often believed that the energetics involved with exchange through openings dominate the SWH $\leftrightarrow$ Channel Exchange ... BUT ...

In MI, when velocities are low, wind and solar heating can be significant.

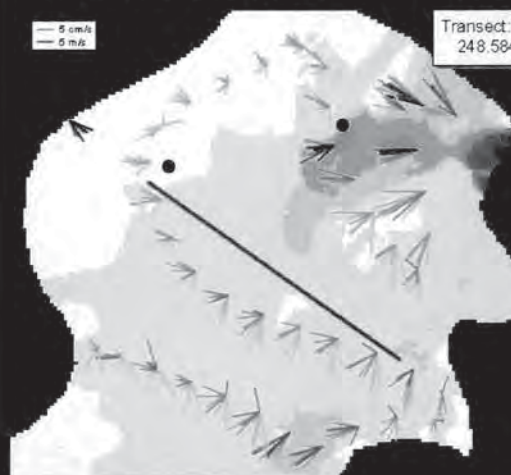
SWH $\leftrightarrow$ Channel Exchange

When barotropic vel is low, wind and/or solar



SWH $\leftrightarrow$ Channel Exchange

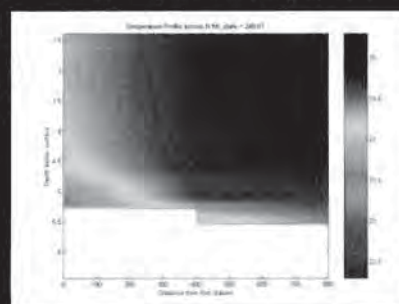
When barotropic vel is low, wind and/or solar



Transect: 08
248.584

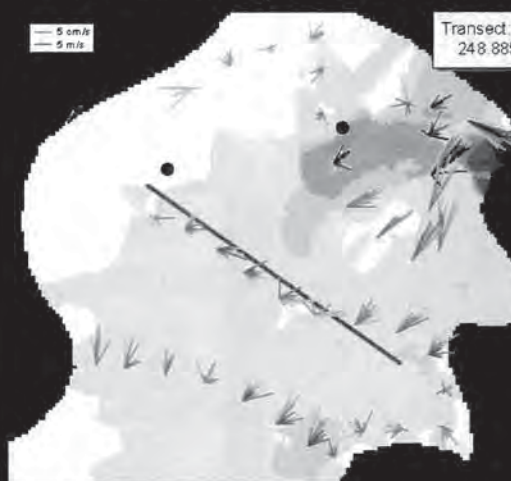
Morning ebb in MI –
Velocities are low
Thermal stratification develops

1hr later –
Wind driven flow at surface
Sets up lateral temp gradient



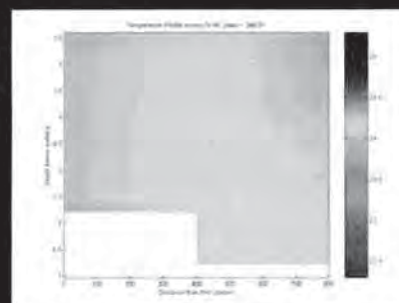
SWH $\leftrightarrow$ Channel Exchange

When barotropic vel is low, wind and/or solar



Transect: 14
248.885

Evening ebb in MI –
Lateral temp gradient persists
Selective withdrawal from E



SWH ↔ Channel Exchange

Lessons Learned

- Orientation of N opening in MI, increases mixing
- When tidal velocities are small (ebb), temperature stratification (limits mixing) and wind-induced flow
- SWH Design Issues
 - Orientation of Breach (not just dimensions) is important
 - May need to consider wind and solar heating

Questions Raised

- Spatially and Temporally, what processes are important (tides/fresh, wind, solar)?
 - ongoing: model development @ UCB
 - map of significance

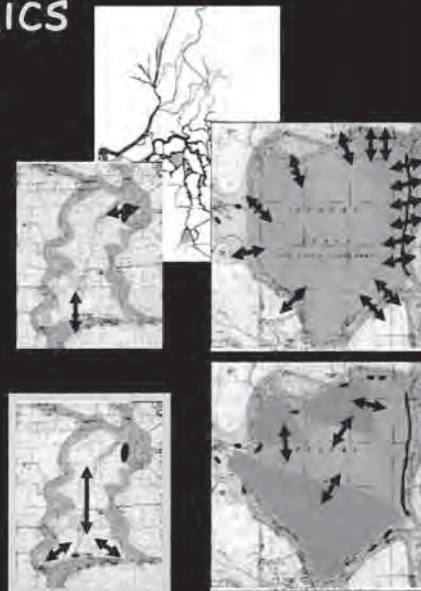
Hydrodynamics and Ecosystem Dynamics

Delta-Scale hydrodynamics set the picture

Transport between SWH and Channels determines residence or flushing times

Exchange between sub-regions or sub-habitats within SWH

Mixing sets detailed distributions of scalars



Interior Mixing within SWH



N MI

- Energetic exchange
 - Tides/fresh very important
 - Wind and temperature structure can create additional asymmetries

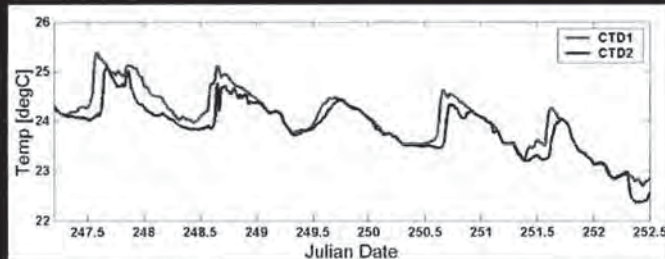
S MI

- Limited connections with channels
 - Tides/fresh significance reduced
 - Wind/Solar more significant
 - Stratification may be persistent

Interior Mixing within SWH

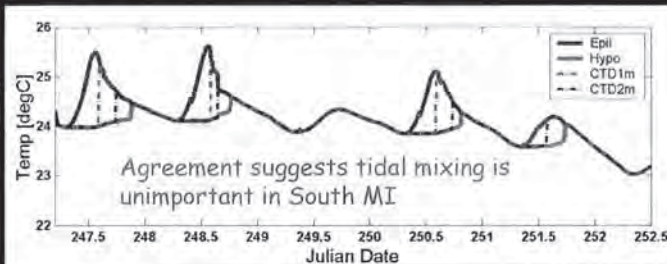
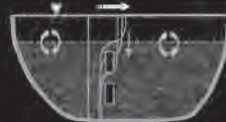
S MI

Field Data:



Check extreme case: atmospheric forcing only

Model:

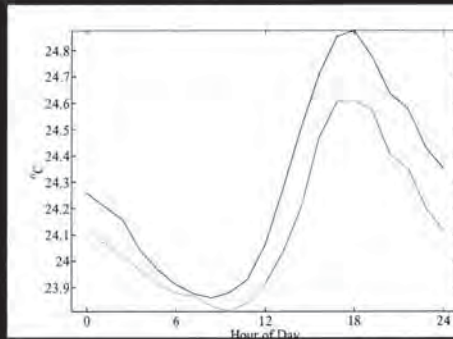


Interior Mixing within SWH

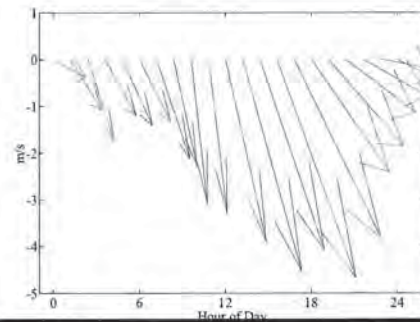
S MI - Average Day

Averaging removes any tidal variability
Focus on Solar and Wind factors

Temperature



Wind

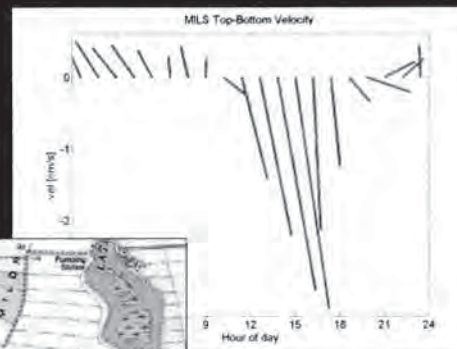
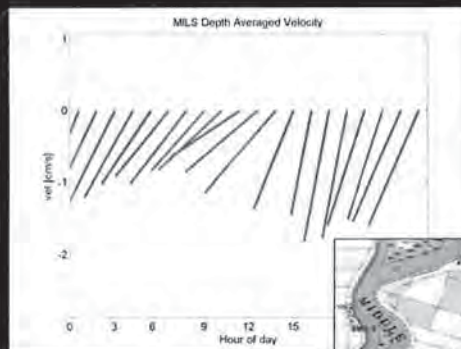


Interior Mixing within SWH

S MI - Average Day

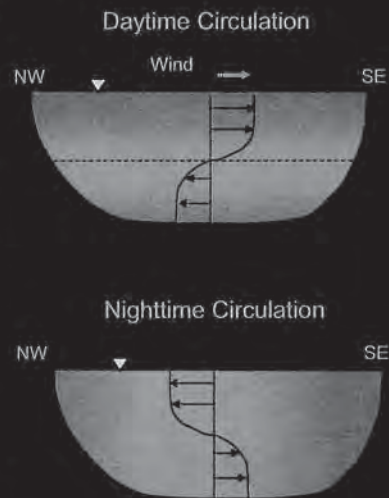
Average over Depth
removes any shear (wind)
residual flux

Top waters relative to bottom
emphasizes shear (wind)



Interior Mixing with SWH

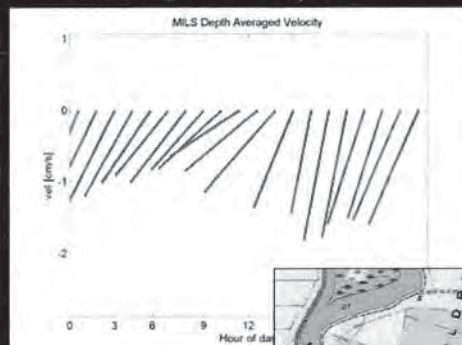
MI - Conceptual Model of Observations



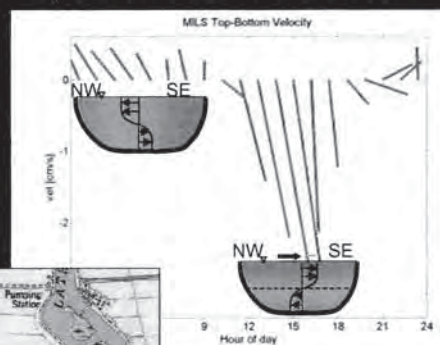
Interior Mixing within SWH

S MI - Average Day

Average over Depth



Top waters relative to bottom

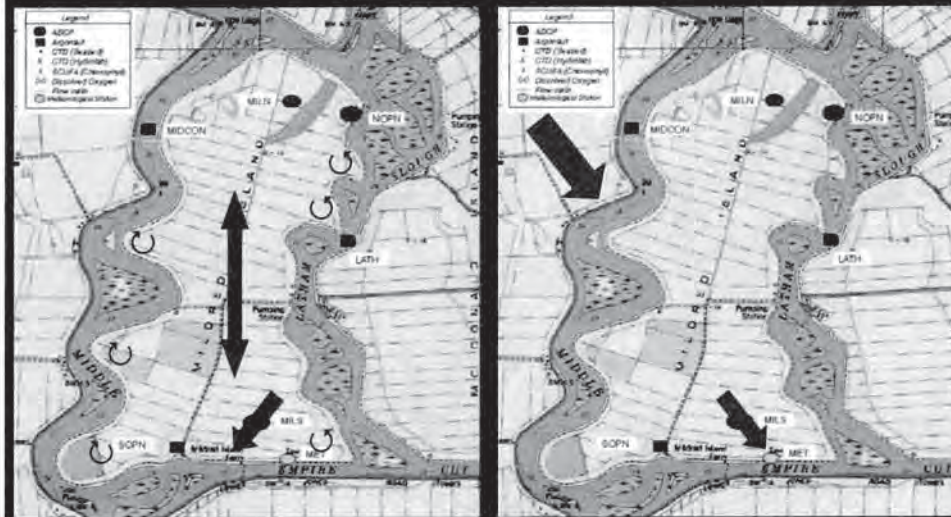


Interior Mixing within SWH

Implications for Flushing of "Quiescent" Areas

Tidal Sloshing

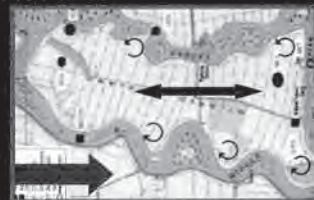
With Wind/Solar Exchange



Internal Mixing within SWH - MI

Lessons Learned

- For S MI and overall circulation, wind and solar heating are significant
 - Since tides/fresh are predominantly N/S and wind has an E/W component, residence time estimates from tides/fresh alone are likely to OVERESTIMATE actual residence time
 - SWH Design Issues
 - Alignment of wind and tide/fresh flow is important is establishing/eliminating quiescent areas (high productivity)
- 
- The map shows San Francisco Bay with arrows indicating tidal currents flowing north-south through the straits. A double-headed arrow at the bottom indicates wind blowing east-west across the bay.



Questions Raised

- Role of temperature stratification and wind (model)
- Importance of vertical shear in setting residence time of quiescent zones (model)
- Se story ... explanation of variability

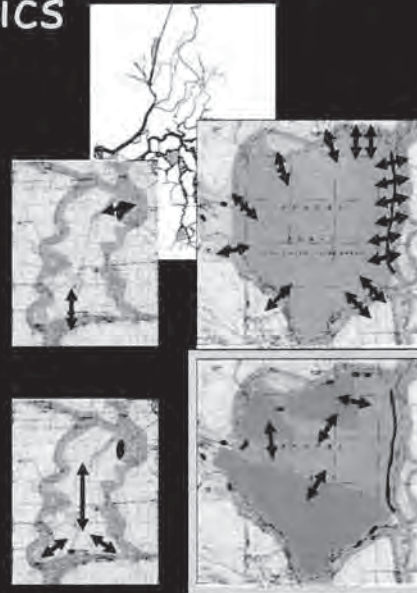
Hydrodynamics and Ecosystem Dynamics

Delta-Scale hydrodynamics set the picture

Transport between SWH and Channels determines residence or flushing times

Exchange between sub-regions or sub-habitats within SWH

Mixing sets detailed distributions of scalars



Interior Mixing within SWH

What about other factors?

- Submerged Aquatic Vegetation (SAV)

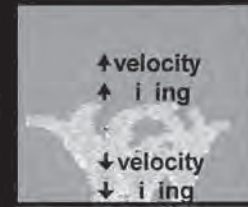
– SAV fills the depth

- Velocity is reduced within SAV
- Mixing energy is reduced within SAV
- Wave energy is reduced; limiting resuspension



– Submerged canopy

- Velocity is reduced within SAV, but can be accelerated above canopy
- Mixing is limited near the bed, but can be strong near the canopy



Ref: Nepf, 2001

Field Methods

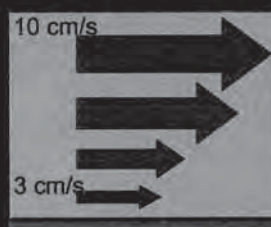
Insitu Instrumentation

- Short-term, high frequency BBL (UC Berkeley)
 - 2-4 ADVs (velocity, pressure)
 - 2 CTs (conductivity, temperature)
 - 2-3 OBSs (suspended particles)
 - 1 SCUFA (Chl fluorescence)

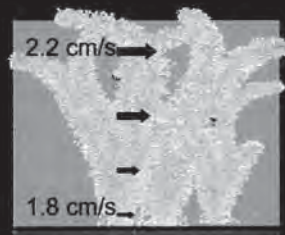


Effects of SAV

Open Water



Within SAV

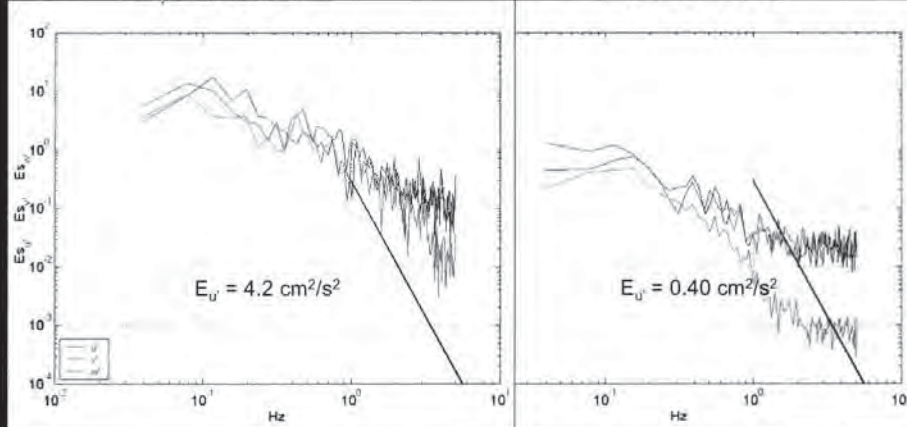


Within SAV:
velocity is reduced by factor of ~5
velocity shear (mixing) reduced

Effects of SAV

Open Water

Within SAV

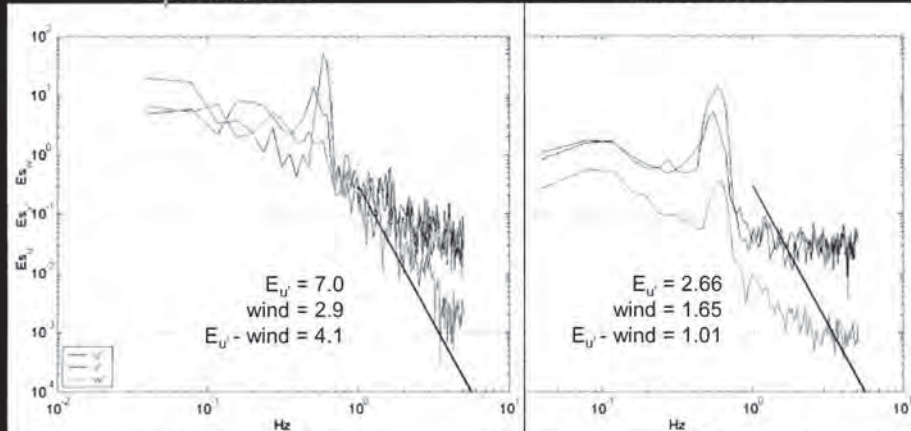


Within SAV:
Mixing energy is reduced by a factor of ~10

Effects of SAV on Wind Waves

Open Water

Within SAV

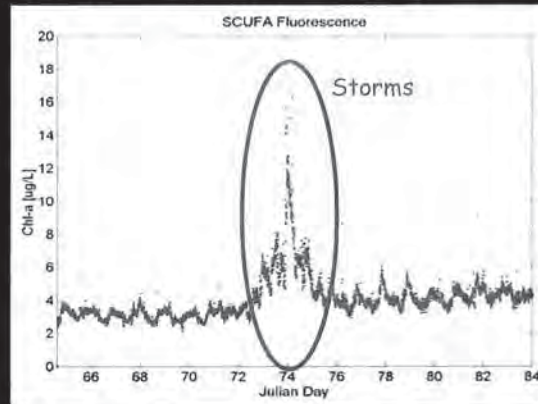


Within SAV:
Wind energy is reduced a factor of ~2
Wind waves are attenuated, limiting resuspension off bed
? resuspension off plants ?

Interior Mixing within SWH

FT

Lots of SAV, but Don't forget about wind!



? Additional fresh water flow
 ? Wind Resuspension from plants
 ? Wind generated transport

Interior Mixing within SWH

FT - Effects of SAV

- Open water vs SAV sites - snapshot
 - SAV decreases velocity by factor of ~5
 - SAV decreases mixing energy by factor of ~10
 - SAV attenuates wave energy by factor ~2
- Develop relationships (pending)
 - SAV velocity = $f(\text{OW vel, SAV height, water depth, SAV density, etc})$
 - SAV mixing = $f(\Delta, \text{location in the SAV})$

Interior Mixing within SWH

FT - Effects of SAV

Lateral mixing

- Gyres due to lateral velocity shear



Vertical mixing

- Gyres due to vertical velocity shear



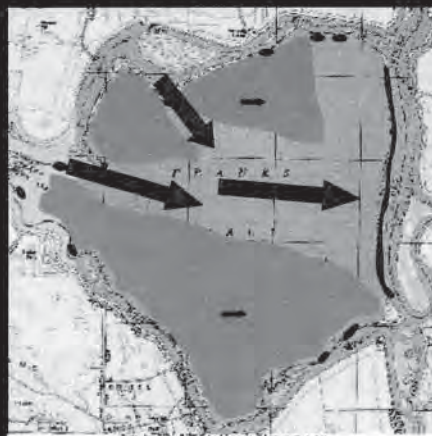
Exchange rate estimates (pending)

Interior Mixing within SWH

FT - Effects of SAV

Residence Time

- Decreases in OW
 - ♦ Drifter ~ 7hrs
 - ♦ Models ~ weeks
- Increases in SAV



Interior Mixing within SWH

FT - Effects of SAV

Preliminary Conceptual Model of Exchange

- Sediment is suspended in Open Water
- Sediment laden water skims over SAV
- Increased mixing in SAV canopy assists in mixing SSC into lower water
- Larger SSC above SAV creates an inverse $c(z)$



Interior Mixing within SWH

FT - Effects of SAV - Pilot Dye Study



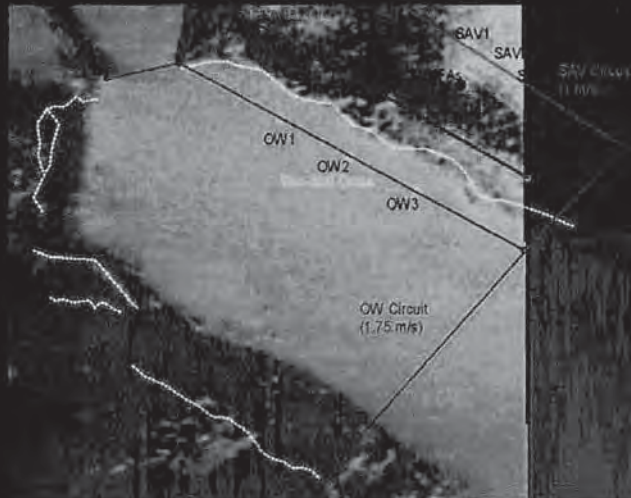
THANKS:
USGS Menlo Park
USGS Sacramento
UC Davis
Turner Designs



Interior Mixing within SWH

FT - Effects of SAV - Pilot Dye Study

Lateral Mixing



Aerial images courtesy
of SFSU Romberg
Tiburon Center and
CA DBW

Interior Mixing within SWH

FT - Effects of SAV - Pilot Dye Study

Vertical Mixing



Aerial images courtesy
of SFSU Romberg
Tiburon Center and
CA DBW

Internal Mixing within SWH - FT

Lessons Learned

- Residence time in Open Water of FT is much shorter than models
- SAV decreases velocity by factor of ~5
- SAV decreases mixing energy by factor of ~10
- SAV attenuates wave energy by factor ~2
- SWH Design Issues (preliminary)
 - Presence of SAV alters residence time
 - SAV may provide a different sub-habitat — exchange rates:

Ongoing Work

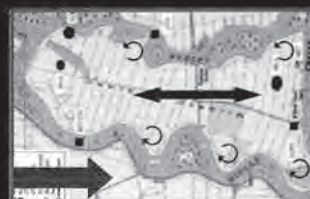
- Velocity / Mixing at different plant density and tidal conditions
- Vertical Mixing Estimations
- Implications for lateral/vertical exchange

Questions Raised

- Feasibility of direct measurement of lateral/vertical exchange (dye study)
- Sedimentation rates for 3 sites within SAV

Summary of SWH Design Issues

- Should consider regional water quality issues
- If residence times are a design issue, may need to consider wind and solar heating
- SAV alters residence time
- SAV may provide a different sub-habitat, & exchange rate between sub-habitats
- unattended levees may deteriorate → leaky habitat
- Orientation of breach can effect amount of mixing/exchange
- Alignment of wind and tide/fresh flow is important in establishing/eliminating quiescent areas



Where do we go from here ?

Ongoing Work

- MI Residence time estimate from SC
- MI Model development incorporating wind and solar heating to create a spatial map of significance
- FT neighborhood/Chl fluxes/clams/etc
- FT Implications for lateral/vertical exchange SAV

Future Directions

- SC as a conservative tracer in the delta (Jon Burau)
- Direct measurement of lateral/vertical exchange with SAV (dye studies) ... Develop a relationship(s) based on plant characteristics and flow characteristics
- Is SAV helping to fill-up FT with sediment?
Sediment cores in open water and within SAV
- Filtering capability of SAV (increase sedimentation)
- How to model SAV? (lab studies w/force transducers)
- Different species of SAV (compare/contrast)
- Effects of matted canopy on the water surface

Acknowledgements

THANKS CALFED !

USGS - Sacramento

Jon Burau, Jay Cuetara, Jon Yokimizo, Curt Battenfeld, Jim DeRose,
Cathy Ruhl, Mike Simpson, Jim George

USGS - Menlo Park

Jim Cloern, Lisa Lucas, Tara Schraga, Cary Lopez, Francis Parchaso

UC Berkeley

Mark Stacey, Bill Dietrich, Seungjin Baek, Jon Fram, Maureen Martin, David Ralston,
Stefan Talke

UC Davis

Bill Fleenor

USDA - ARS Weed Science Program

Lars Anderson

CA DWR

Lenny Grimaldi

California State Water Project
Watershed Sanitary Survey
2011 Update



Prepared for The State Water Project Contractors Authority
and the California Department of Water Resources

Prepared by Archibald Consulting,
Palencia Consulting Engineers, Starr Consulting

June 2012

EXECUTIVE SUMMARY

CONTENTS

SYSTEM ENVIRONMENT	ES-1
Drinking Water Regulations	ES-1
Source Water Protection Regulations	ES-3
Biological Opinions	ES-4
Policy Setting	ES-4
WATER QUALITY IN THE WATERSHEDS AND THE STATE WATER PROJECT	ES-5
Water Quality Trends	ES-5
Long-term Trends	ES-6
Spatial Trends	ES-6
Wet Year and Dry Year Trends	ES-8
Taste and Odor Incidents and Algal Toxins	ES-10
Pathogens	ES-11
Constituents of Emerging Concern	ES-11
KEY WATER QUALITY VULNERABILITIES OF THE SACRAMENTO-SAN	
JOAQUIN DELTA	ES-12
Wastewater Treatment Plants	ES-12
Urban Runoff	ES-13
Delta Land Conversions	ES-13
Recreational Use of the Delta	ES-14
KEY WATER QUALITY VULNERABILITIES OF THE STATE WATER PROJECT	ES-15
North Bay Aqueduct	ES-15
Clifton Court Forebay	ES-15
South Bay Aqueduct	ES-15
Delta-Mendota Canal/California Aqueduct Intertie	ES-16
San Luis Reservoir	ES-16
Coastal Branch	ES-16
Non-Project Inflows	ES-17
Subsidence Along the Aqueduct	ES-18
Pyramid Lake	ES-19
Castaic Lake	ES-19
Hesperia Master Drainage Plan	ES-19
Silverwood Lake	ES-20
Lake Perris	ES-20
STATE WATER PROJECT FACILITY OPERATIONS VULNERABILITIES	ES-20
Biological Opinions	ES-21
Head of Old River Barrier	ES-21
Impacts of Drought on Water Quality	ES-22
FINDINGS AND RECOMMENDATIONS	ES-22

FIGURES

Figure ES-1. The State Water Project	ES-2
--	------

EXECUTIVE SUMMARY

The State Water Project (SWP) provides drinking water to approximately two-thirds of California's population and is the nation's largest state-built water development project. The SWP extends from the mountains of Plumas County in the Feather River watershed to Lake Perris in Riverside County. **Figure ES-1** shows the major features of the SWP. Four previous SWP watershed sanitary surveys were completed in 1990, 1996, 2001, and 2006, so the contaminant sources and water quality issues have been well documented. The California State Water Project Watershed Sanitary Survey, 2011 Update (2011 Update) focuses on evaluating the sources of the water quality problems that the SWP Contractors face and recommending actions that they can take to protect source water quality.

SYSTEM ENVIRONMENT

The System Environment chapter contains a discussion of drinking water regulations and source water protection regulations. This chapter also contains a discussion of the potential water quality implications of the biological opinion issued by the U. S. Fish and Wildlife Service (USFWS) to protect delta smelt and the biological opinion issued by the National Marine Fisheries Service (NMFS) to protect Chinook salmon, several other anadromous fish, and killer whales. The various programs aimed at restoring the Sacramento-San Joaquin Delta (Delta) ecosystem while enhancing water supply reliability are also discussed. Key findings and recommendations from the System Environment chapter are presented in the following paragraphs of this section.

DRINKING WATER REGULATIONS

The U.S. Environmental Protection Agency (USEPA) finalized a number of key drinking water regulations in the last five years, including the Stage 2 Disinfectants and Disinfection Byproducts Rule and the Long Term 2 Enhanced Surface Water Treatment Rule. Key federal regulations that are being developed are:

- The Unregulated Contaminant Monitoring Rule 3 – This rule is scheduled to be finalized in 2012.
- The USEPA Health Effects Assessments – Health effects assessments are being completed for acrylamide, trichloroethylene, and tetrachloroethylene.
- USEPA Drinking Water Strategy – In February 2011, USEPA announced that it will move forward with development of regulatory standards for a group of 16 carcinogenic volatile organic compounds. The USEPA also announced that the second group of contaminants to be addressed will be nitrosamine disinfection byproducts.

- Perchlorate – In February 2011, USEPA announced that it will develop a regulation for perchlorate under the Safe Drinking Water Act. A proposed rule is expected in early 2013 with a final rule by mid-2014.

Figure ES-1. The State Water Project



In the last five years, the California Department of Public Health (CDPH) reduced the arsenic MCL from 50 to 10 µg/L and the Office of Environmental Health Hazard Assessment (OEHHA) published a chromium (VI) Public Health Goal (PHG). Key California regulations that are being developed are:

- Perchlorate – OEHHA proposed a revised PHG of 1 µg/L in January 2011. OEHHA published the results of an external peer review in November 2011 and is currently developing a revised draft PHG for public review. OEHHA currently does not have a schedule for issuing the final PHG.
- Chromium (VI) – OEHHA released the final PHG of 0.02 µg/L in July 2011. CDPH will establish a Maximum Contaminant Level (MCL) in the next several years.
- Total Trihalomethanes (TTHM) – OEHHA issued a draft PHG of 0.8 µg/L for TTHM in September 2010. OEHHA is in the process of establishing the final PHG but does not yet have a schedule for completing the process.

SOURCE WATER PROTECTION REGULATIONS

Source water protection is a key component of the multi-barrier approach to protecting drinking water quality. California has adopted many regulations to protect source water quality and there are several source water protection regulations that are under development. Key regulations that are being developed are:

- Industrial Stormwater General Permit – The State Water Resources Control Board (State Water Board) has proposed changes to the Industrial Stormwater General Permit. The State Water Board staff is responding to comments submitted in April 2011.
- Irrigated Lands Regulatory Program – The Central Valley Regional Water Quality Control Board (Central Valley Regional Water Board) is developing a long-term regulatory program to replace the interim program.
- Proposed Statewide Nutrient Policy – The State Water Board is developing a new regulatory program for nutrients in inland surface waters.
- Total Maximum Daily Loads (TMDLs) – The Central Valley Regional Water Board is currently developing mercury and DO TMDLs and a Central Valley TMDL for diazinon and chlorpyrifos. The board is planning to work on a Central Valley TMDL for pyrethroid pesticides in the near future.
- Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS) – This is a multi-year effort to address salt, boron, and nitrate in the Central Valley.

- Central Valley Drinking Water Policy – This is a multi-year effort to develop a policy to protect source water quality for key drinking water constituents. The Drinking Water Policy is currently under development and will be considered by the Central Valley Regional Water Board in July 2013.

BIOLOGICAL OPINIONS

USFWS is required to issue biological opinions on projects that have the potential to impact federally listed threatened and endangered species. Similarly, NMFS is required to issue biological opinions on projects that have the potential to impact federally listed marine and anadromous fish species. Biological opinions have been issued for delta smelt by the USFWS and for winter-run and spring-run Chinook salmon, steelhead, green sturgeon, and killer whales by NMFS. The biological opinions were challenged by the State Water Contractors and other water organizations and were revised and challenged again. Both USFWS and NMFS are currently revising the biological opinions.

POLICY SETTING

In the last five years, there have been numerous activities and programs aimed at restoring the Bay-Delta ecosystem and improving water supply reliability. The key ongoing activities that address water quality or could impact water quality in the Delta are:

- The Delta Stewardship Council's Delta Plan – The Delta Plan is scheduled for adoption in the fall of 2012.
- The Delta Conservancy's Strategic Plan – The Strategic Plan is scheduled for completion by early 2013.
- The Bay Delta Conservation Plan (BDCP) – A public review draft BDCP is expected to be completed by September 2012. Following a public review period, a final BDCP will be prepared. The impacts of the plan on environmental and drinking water quality will be evaluated in the Environmental Impact Report/Environmental Impact Statement (EIR/EIS) which is on the same schedule as the BDCP.
- USEPA Advanced Notice of Proposed Rulemaking (ANPR) – USEPA Region 9 issued an ANPR on February 10, 2011. This ANPR initiates an assessment of the effectiveness of current programs designed to protect ecosystem water quality and aquatic species habitat in the Bay Delta Estuary. USEPA expects to release a synthesis report in the spring of 2012 and then determine if new regulations are needed.
- San Joaquin River Restoration Program – The effort to restore the San Joaquin River involves restoring flows to about 60 miles of dry river bed and significant improvements to channels, levees, and fish passages. There have not been any studies done on the impact of the increased flows on water quality in the San Joaquin River and at the Delta pumping plants.

- Delta Wetlands Project – The Delta Wetlands Project involves creating storage reservoirs on Webb Tract and Bacon Island and creating wetlands and wildlife habitat on Bouldin Island and Holland Tract in the central Delta. The Final EIR on the project was certified in September 2011. Delta Wetlands Properties is currently pursuing a water right permit with the State Water Board.

WATER QUALITY IN THE WATERSHEDS AND THE STATE WATER PROJECT

Ten chapters of the report address water quality constituents having the capacity to cause drinking water standards to be violated or to reduce the quality of drinking water supplies conveyed through the SWP. Although there are potentially numerous constituents in drinking water sources, the key water quality challenges facing the SWP Contractors that treat water from the SWP are balancing the formation of disinfection by-products, due to high concentrations of organic carbon and bromide in the source water, with removing and inactivating pathogens such as *Giardia* and *Cryptosporidium*; high nutrient concentrations that lead to algal blooms, taste and odor problems, and operational problems; and high levels of total dissolved solids that create challenges with blending, groundwater recharge, and wastewater recycling. The water quality chapters are organized as follows:

- Chapter 3 – Water Quality Background and Summary
- Chapter 4 – Organic Carbon
- Chapter 5 – Salinity
- Chapter 6 – Bromide
- Chapter 7 – Nutrients
- Chapter 8 – Taste and Odor Incidents and Algal Toxins
- Chapter 9 – Turbidity
- Chapter 10 – Pathogens
- Chapter 11 – Organic Chemicals and Trace Elements
- Chapter 12 – Constituents of Emerging Concern

The Department of Water Resources (DWR) Municipal Water Quality Investigations (MWQI) Program and the Division of Operations and Maintenance (O&M) conduct a comprehensive water quality monitoring program of the Delta and the SWP facilities. The long period of record at many locations allows the data to be analyzed for spatial trends, long-term trends, and seasonal trends. Most of the data has been entered into DWR's Water Data Library. This online database is a valuable tool that provides easy access to the data shortly after it has been collected.

WATER QUALITY TRENDS

All available water quality data at a number of locations in the watersheds, the Delta, and along the SWP facilities were evaluated for the 2011 Update. The organic carbon, salinity, bromide, nutrient, and turbidity data were evaluated to determine if there are long-term trends, spatial trends, and differences between wet and dry years.

Long-term Trends

There are no apparent long-term trends in the water quality data at any of the locations evaluated for this project. In 2009, MWQI staff conducted a long-term trend analysis for the Sacramento River at Hood (Hood), the San Joaquin River at Vernalis (Vernalis), and the Harvey O. Banks Delta Pumping Plant (Banks). Trends were analyzed for the entire period of record through 2008 at each location and for the 1999 to 2008 period. Different results were obtained for the different periods of time. For example, the analysis showed a declining trend in dissolved organic carbon (DOC) at all three locations during the longer period and an increasing trend at Hood and Vernalis and no trend at Banks during the more recent period. This analysis showed that trends are very much a function of the hydrology of the system during the starting and ending points of the analysis. Another total organic carbon (TOC) trend analysis conducted at Banks between 1990 and 2003 by O&M staff reached the same conclusion. O&M staff conducted an assessment of long-term salinity trends at Banks using data from 1970 to 2002 and concluded that the salinity in SWP exports has neither increased nor decreased over that period. Visual inspection of time series graphs for a number of other constituents and locations also shows that water quality trends can be explained by evaluating the hydrologic conditions at the start and end of the trend analysis period.

Spatial Trends

The data were analyzed to determine if water quality changes as the water flows down the Governor Edmund G. Brown California Aqueduct (California Aqueduct) and is stored in reservoirs. Factors that could potentially affect water quality include:

- North Bay Aqueduct (NBA) – The NBA is an enclosed pipeline so water quality should not change between Barker Slough and the water treatment plant intakes.
- Banks to South Bay Aqueduct (SBA) Terminal Tank – Water from Lake Del Valle enters the SBA below Del Valle Check 7 (DV Check 7). This primarily affects SBA water quality in the fall months when releases are made to the SBA.
- Banks to O'Neill Forebay – There are no inputs to the California Aqueduct in this reach.
- O'Neill Forebay and San Luis Reservoir – Water from the Delta-Mendota Canal (DMC) mixes with water from the California Aqueduct in O'Neill Forebay. Storage in San Luis Reservoir and the timing of filling and releases from the reservoir can potentially impact water quality.
- San Luis Canal Reach of the California Aqueduct – Local streams that run eastward from the Coastal Range Mountains bisect the aqueduct at various points. During storms, water from some of these streams enters the aqueduct.
- Coastal Branch of the California Aqueduct – The Coastal Branch is 115 miles long; the first 15 miles are open aqueduct and the remainder is a pipeline. No drainage enters the open canal section.

- California Aqueduct between Check 21 and Check 41 – This reach of the aqueduct is used to convey both surface water and groundwater non-Project inflows acquired through transfers and exchanges among local agencies. The quality of the non-Project inflows can affect the quality of the water in the aqueduct. This topic is addressed in Chapter 14.
- West Branch of the California Aqueduct – Pyramid and Castaic lakes provide almost 500,000 acre-feet of storage, which greatly reduces the fluctuations in water quality seen in the aqueduct. Natural inflow from the watersheds of the reservoirs can affect water quality during substantial storm events.
- East Branch of the California Aqueduct – Silverwood Lake has a capacity of only 74,970 acre-feet and does not moderate water quality the way the West Branch reservoirs do. Natural inflow from its watershed can affect water quality at times.

This analysis included an evaluation of all of the data at each monitoring location. The data collected during comparable periods of time at all locations were analyzed to draw conclusions about spatial trends. The data were statistically analyzed using the non-parametric Mann-Whitney test which determines if the data sets being compared are statistically different. The median concentrations are representative of the entire data set. The key findings are:

- Median TOC concentrations do not change as water flows from the Delta through the SBA and the California Aqueduct when data collected during comparable periods of time are aggregated and analyzed. The median TOC concentrations along the aqueduct range from 3.0 to 3.2 mg/L. San Luis Reservoir and Castaic Lake have less variability in TOC concentrations than the aqueduct due to the dampening effect of reservoir mixing. The dampening effect is not seen in Silverwood Lake on the East Branch due to its limited hydraulic residence time. When examined on a finer time scale, differences in TOC occur between O'Neill Forebay Outlet and Check 21. The peak concentrations of TOC at Check 21 occurred approximately one month later than at O'Neill Forebay Outlet in 2008, 2009, and 2010 and the peak concentrations were about 1 mg/L lower at Check 21. The shift in the timing of the peak is likely due to low flows in the aqueduct during this period. The lower TOC concentrations at Check 21 compared to O'Neill Forebay Outlet during the 2007 to 2010 period are inexplicable. A small amount of groundwater (12,581 acre-feet) was pumped into this reach of the aqueduct by Westlands Water District (Westlands) in the summer of 2008, but that does not explain the differences during the spring of 2008, 2009, and 2010. Changes in TOC concentrations are apparent in the aqueduct during periods when non-Project inflows are introduced between Checks 21 and 41.
- Although there are no apparent differences in median TOC concentrations when all available data are aggregated, the quality of organic carbon changes. Water in San Luis Reservoir has a greater propensity to form disinfection byproducts during the spring and summer months. This is the period when most water is released from the reservoir and flows south in the California Aqueduct.

- Changes to electrical conductivity (EC) in the California Aqueduct and SWP reservoirs are complex. There is a statistically significant increase of 63 $\mu\text{S}/\text{cm}$ between Banks and O'Neill Forebay Outlet due to storage in San Luis Reservoir and to mixing with water from the more saline DMC in O'Neill Forebay. However, there is not a significant change in EC between O'Neill Forebay Outlet and Check 21. There is a statistically significant decrease in EC between Check 21 and Check 41 of 16 $\mu\text{S}/\text{cm}$. This is likely due to non-Project inflows of lower EC water in recent years. The median EC at Castaic Lake Outlet (Castaic Outlet) is 57 $\mu\text{S}/\text{cm}$ higher than at Check 41 but there is no significant change between Check 41 and Devil Canyon Afterbay (Devil Canyon).
- There is a statistically significant increase in bromide concentrations between Banks (median of 0.18 mg/L) and O'Neill Forebay Outlet (median of 0.22 mg/L) due to the release of water from San Luis Reservoir that has high bromide concentrations (median of 0.25 mg/L). Bromide does not change significantly between O'Neill Forebay Outlet and Check 21. The median bromide concentration of 0.21 mg/L at Check 41 is not statistically different from the median bromide concentration of 0.22 mg/L at Check 21. However, during periods when non-Project inflows are introduced to the aqueduct, the bromide concentrations at Check 41 are lower than the concentrations at Check 21. The median bromide concentration at Castaic Outlet of 0.21 mg/L is the same as at Check 41. The median bromide concentration at Devil Canyon of 0.19 mg/L is not statistically different from the median bromide concentration of 0.21 mg/L at Check 41.
- Turbidity levels are quite variable as water moves down the aqueduct but the impact of settling in reservoirs is quite apparent in that median turbidity levels in the reservoirs are 1 to 2 NTU.
- Nutrient concentrations do not change as water flows from the Delta through the SBA and the California Aqueduct. Median total nitrogen (total N) concentrations are about 1.0 mg/L and median total phosphorus (total P) concentrations are about 0.1 mg/L throughout the system. Nutrient concentrations are substantially lower in Castaic Lake and Lake Perris.

Wet Year and Dry Year Trends

The data were analyzed to determine if there are water quality differences between wet years and dry years. Wet years are defined as those that are classified by DWR as wet and above normal. Dry years are defined as those that are classified as below normal, dry, and critical.

- There are no statistically significant differences between median TOC concentrations in dry years and wet years at many of the locations along the aqueduct.

- EC levels during dry years are statistically significantly higher than EC levels during wet years at all locations except Barker Slough and Castaic Outlet. There were no statistically significant differences between year types at these two locations. The higher levels during dry years are due to less dilution of agricultural drainage, urban runoff, and wastewater discharged to the rivers and Delta during low flow periods and to seawater intrusion in the Delta during periods of low Delta outflow.
- Bromide concentrations during dry years are statistically significantly higher than bromide concentrations during wet years at all locations except Barker Slough. There were no significant differences between year types at this location. The median bromide concentrations during dry years are 50 to 100 percent higher than the median concentrations during wet years. This is due primarily to seawater intrusion in the Delta during periods of low Delta outflow.
- Turbidity levels are statistically significantly lower during dry years than wet years at most locations that were included in this analysis. At several locations, including San Luis Reservoir and Castaic Lake, there was no significant difference between dry and wet years.
- Comparison of nutrient concentrations in dry years and wet years does not produce a consistent pattern throughout the system. At many locations, there are no differences between dry and wet years. At Hood and Vernalis, total P concentrations are not statistically different between dry years and wet years but total N concentrations are statistically significantly higher during dry years. This may be due to the greater influence of the Sacramento Regional Wastewater Treatment Plant at Hood and to agricultural drainage at Vernalis. At Pacheco Pumping Plant in San Luis Reservoir (Pacheco), both total N and total P are statistically significantly lower in dry years. This is likely due to algal uptake and settling in the reservoir since samples are collected in the epilimnion of the reservoir more frequently during dry years when water levels are lower. The pattern at Castaic Lake is different with both total N and total P being statistically significantly higher in dry years. Check 41 and Devil Canyon show the same pattern of higher total N concentrations in dry years and lower total P concentrations in dry years. This may be related to non-Project inflows that occur more frequently in dry years.
- Median total P concentrations in dry years and wet years are the same at most locations. Dry year total P medians are statistically significantly lower than wet year medians at Pacheco, Check 41, Castaic, and Devil Canyon. Dry year total N medians are statistically significantly higher than wet year medians at about half of the locations and the same at the other locations.

TASTE AND ODOR INCIDENTS AND ALGAL TOXINS

Monitoring of 2-methylisoborneol (MIB) and geosmin, the two compounds most often responsible for taste and odor (T&O) problems, was initiated at a number of locations in the SWP between 2001 and 2005. Monitoring was initiated for the NBA in 2009. The samples are quickly analyzed and email reports are sent to the SWP Contractors alerting them to potential T&O problems.

- The NBA Contractors experienced a severe T&O episode in February 2009 that resulted in numerous customer complaints when geosmin concentrations quickly increased to over 300 ng/L. The likely T&O producer was *Aphanizomenon gracile*. The NBA had to be shut down for over six weeks, resulting in a significant loss of Delta water for the NBA Contractors. The Solano County Water Agency works with DWR to monitor T&O compounds and to periodically treat Campbell Lake, a small impoundment upstream of the Barker Slough Pumping Plant. The combination of monitoring to detect problems and treatments has been effective since the NBA users have had no further customer complaints.
- Problematic levels of MIB and geosmin occur in the Delta, along the California Aqueduct, and in southern California reservoirs. MIB and geosmin peaks in excess of 10 ng/L have occurred at Clifton Court Forebay (Clifton Court) every summer since monitoring was initiated in 2003. Geosmin concentrations have exceeded 10 ng/L every year and MIB concentrations have exceeded 10 ng/L in five of the ten years that monitoring has been conducted at Banks.
- The peak levels of MIB and geosmin at Banks are quickly transported to the SBA. MIB and geosmin concentrations at DV Check 7 exceeded 10 ng/L every summer between 2003 and 2007 and again in 2010. MIB from the Delta is transported down the California Aqueduct to O'Neill Forebay Outlet but the concentrations decrease with distance down the aqueduct. Castaic Lake has extremely high levels of geosmin every summer (up to 830 ng/L) and occasional MIB peaks greater than 10 ng/L. Silverwood Lake has peaks of both compounds that exceed 10 ng/L but do not reach the high levels found in Castaic Lake.

DWR has monitored *Microcystis aeruginosa* blooms for their ecological consequences for a number of years. Monitoring for microcystins in drinking water supplies started in 2006.

- *M. aeruginosa* blooms have occurred routinely in the summer months in the Delta since 1999. While blooms are found throughout the Delta, the highest cell densities are routinely found in the south Delta in the Old River and the Middle River.
- DWR conducted cyanotoxin monitoring at various locations in the SWP for four years. In 2007, microcystin-LR was detected at all locations that were monitored, except Barker Slough. It was below the reportable limit of 1 µg/L.

PATHOGENS

All SWP Contractors have completed their Long Term 2 Enhanced Surface Water Treatment Rule monitoring and all have been classified in Bin 1, meaning *Cryptosporidium* levels are low (running annual average of less than 0.075 oocysts/L), so no additional action related to *Cryptosporidium* is required at this time. An evaluation of the total coliform, fecal coliform, and *E. coli* data indicates that 2-log *Cryptosporidium*, 3-log *Giardia*, and 4-log virus removal and inactivation is the appropriate level of treatment for all SWP Contractors.

There were limitations in conducting statistical analysis of the coliform data at some sampling locations due to peak values being reported as greater than an upper limit, rather than being enumerated. This is due to insufficient dilution of the samples.

CONSTITUENTS OF EMERGING CONCERN

Studies on the occurrence, fate, and transport; health effects; analytical methods; and removal of constituents of emerging concern (CECs) in drinking water and wastewater have been completed in the last five years. The five most frequently detected chemicals in surface water in a recent nationwide study were cholesterol, metolachlor, cotinine, β -sitosterol, and 1,7-dimethylxanthine. Another study showed the five most frequently detected chemicals in surface waters were sulfamethoxazole, carbamazepine, atrazine, phenytoin, and meprobamate.

In 2010, the National Water Research Institute (NWRI), Metropolitan Water District of Southern California (MWDSC), and Orange County Water District completed a source, fate, and transport study of endocrine disrupting compounds (EDCs) and pharmaceuticals and personal care products (PPCPs) that included eleven sampling sites associated with the SWP. Of the 49 PPCPs and organic wastewater contaminants analyzed, 21 analytes were detected at or above the minimum reporting level, whereas the other 28 were not detected at any of the locations with the existing minimum reporting levels. The six most frequently detected CECs were carbamazepine, diuron, sulfamethoxazole, caffeine, primidone, and tris (2-chloroethyl) phosphate (TCEP). The highest concentrations of many of the most frequently detected compounds were found in samples from the San Joaquin River at Holt Road, just downstream of the Stockton Regional Wastewater Control Facility. Certain PPCPs (carbamazepine, primidone, gemfibrozil, and sulfamethoxazole) are highly attenuated as water moves downstream along the California Aqueduct. However, detectable levels of some PPCPs were found at terminal reservoirs in southern California. The NWRI study concluded there is no evidence of human health risk from low levels of the commonly detected EDCs and PPCPs in drinking water or drinking water supplies; however, more toxicological studies are needed.

MWDSC and DWR completed a two-year study in April 2010 of the sources and occurrence of N-nitrosodimethylamine (NDMA), other nitrosamines, and their precursors in the Delta. The only instantaneous nitrosamine detected was NDMA, once at the Mossdale sampling location at 4.2 ng/L, and once at the Vernalis sampling location at 2.5 ng/L. NDMA formation potential concentrations were generally two to four times higher downstream of the Stockton and Sacramento wastewater treatment plants. The second phase of this study began in early 2011.

The State Water Board convened a CEC Science Advisory Panel to develop guidance for the establishment of monitoring programs to assess potential CEC threats from water recycling activities. The final report identified four indicator compounds based on their toxicological relevance for groundwater recharge projects: NDMA, 17 beta-estradiol, caffeine, and triclosan. Four additional CECs were identified as viable performance indicators (N,N-Diethyl-meta-toluamide (DEET), gemfibrozil, iopromide, and sucralose).

KEY WATER QUALITY VULNERABILITIES OF THE SACRAMENTO-SAN JOAQUIN DELTA

Chapter 13 contains a discussion of the key water quality vulnerabilities of the Delta. The key vulnerabilities and contaminant sources throughout the watershed have been documented in previous updates. The CDPH, SWP Contractors, and DWR identified the Delta vulnerabilities to be addressed in the 2011 Update. The key findings for each of the specific topics discussed in Chapter 13 are presented in the following paragraphs of this section.

WASTEWATER TREATMENT PLANTS

There are 12 wastewater treatment plants that discharge directly to the Delta and many others that discharge to tributaries of the Delta. Wastewater treatment plants in the SWP watershed currently discharge 346 million gallons per day (mgd) based on average dry weather flow. The current average dry weather flow design capacity of wastewater treatment plants in the Central Valley is 560 mgd, indicating that wastewater agencies are planning for growth and increased volumes of wastewater.

The DWR Modeling Section has recently developed a fingerprint that includes wastewater volumes from three of the largest treatment plants that discharge to the Delta. These three wastewater plants represent 82 percent of the wastewater volume discharged to the Delta so the fingerprints are a good estimation of the overall percent of wastewater at Delta pumping plants. The wastewater contribution at Clifton Court and the C.W. "Bill" Jones Pumping Plant (Jones) ranges from zero to about three percent.

Regulatory management of wastewater dischargers has increased significantly through implementation of more stringent National Pollutant Discharge Elimination System (NPDES) permit effluent limits and special study requirements. Most wastewater dischargers have upgraded to tertiary treatment and several other facilities are required to upgrade within the next ten years.

There are limited data on the concentrations of key drinking water constituents in wastewater effluent because NPDES monitoring programs do not include many of the key drinking water constituents.

There were few spill events at the wastewater treatment plants, but numerous collection system failures resulted in discharges to receiving waters. Most were related to sewer line blockage or failure.

URBAN RUNOFF

Urban runoff from Sacramento, Stockton, eastern Contra Costa County, and a number of small communities is discharged to the Delta. A number of other communities discharge urban runoff to Delta tributaries.

Urban runoff in the Central Valley and Delta is regulated by the Central Valley Regional Water Board through Municipal Separate Storm Sewer System NPDES permits. These permits require large (greater than 250,000 population) and medium (100,000 to 250,000 population) municipalities (designated as Phase I permittees) to develop stormwater management plans and conduct monitoring of stormwater discharges and receiving waters. Small communities (less than 100,000 population) are Phase II permittees. They are required to develop management plans but historically did not have to conduct monitoring. Monitoring may be required when the new Phase II permit is issued later this year. The permits require the communities to implement best management practices (BMPs) and conduct special studies. The permits for the larger Phase I permittees require low impact development for new development, which involves designing and maintaining facilities to manage urban runoff onsite to maintain runoff volumes at pre-development levels.

Urban runoff levels of bacteria, nutrients, and organic carbon are much higher than the receiving waters. Generally, these constituents are seen at higher levels during wet weather events.

The stormwater permits do not contain effluent limitations for specific water quality constituents but do require municipalities to reduce urban runoff pollution to the maximum extent practicable through implementation of BMPs. There are limited data on the effectiveness of BMPs in reducing drinking water constituents of concern, such as organic carbon, nutrients, and pathogens. Based on the limited studies that have been conducted, retention and detention ponds seem most effective at reducing drinking water constituents of concern. Data from a new retention basin in Sacramento support this finding.

DELTA LAND CONVERSIONS

There are a number of habitat restoration projects that are underway or being planned in the Delta. Conversion of agricultural lands to tidal marsh is called for by the Ecosystem Restoration Program's Conservation Strategy for Sacramento-San Joaquin Delta Ecological Management Zone and by the BDCP. Other ecosystem restoration projects may occur through the Sacramento-San Joaquin Delta Conservancy, and the Delta Wetlands project (discussed in Chapter 2). DWR currently has three habitat restoration projects underway.

There is consensus that DOC production will increase as a result of converting agricultural land into tidal wetlands. Recent studies have also shown that an expansion of wetlands has the potential for raising Delta dissolved organic matter concentrations in spring and early summer. Therefore, restoration may shift the overall DOC peak towards spring and summer, later than the current winter peak. This temporal shift in DOC loading may affect the overall loading to drinking water since more water is typically pumped during the spring and summer than during the winter.

Conversion of the Delta's traditional cultivated fields to managed wetlands or rice crops shows potential for stopping and reversing the effects of subsidence as well as potentially serving as a means of carbon sequestration. DWR and the U.S. Geological Survey (USGS) are jointly working on two major types of pilot projects on Delta islands to assess their effectiveness for subsidence reversal and carbon sequestration. These projects are part of the DWR Interim Delta Actions to continue incremental improvements in the Delta until a long-term solution is in place. These projects include managed wetlands and rice cultivation, both of which include flooding Delta islands.

Studies conducted to date indicate that there is great opportunity for subsidence reversal and carbon capture through wetlands and rice cultivation in the Delta. It is still uncertain if widespread implementation of these projects will occur in the Delta. The studies have included evaluation of the potential impacts to receiving waters, in particular the contribution of DOC. Wetlands and rice cultivation have been shown to both contribute elevated amounts of DOC in the drainages, particularly in the seepage flows through shallow groundwater. The highest loading of DOC from both wetlands and rice occurred during the summer months. Additional studies on the managed wetlands and rice crops will further examine the amount, extent, and potential factors influencing the transport of DOC to receiving waters.

RECREATIONAL USE OF THE DELTA

The Delta Protection Commission has estimated that there are over 12 million visitors to the Delta annually, including about 500,000 boaters. This includes shoreline recreation (picnicking, hiking, camping, and hunting), boating, fishing, water-skiing, and other recreational activities along the Delta's 57,000 acres of navigable waterways. All of these activities have the potential to impact water quality in the Delta. Recreational use of the Delta is projected to increase in the future as population increases. Recreational users may not be aware of the significance of the Delta as a drinking water source.

The California Department of Parks and Recreation prepared a Recreation Proposal for the Sacramento-San Joaquin Delta and Suisun Marsh in May 2011. This plan will be included with the Delta Plan that will be finalized in the fall of 2012. The plan calls for creation of wildlife habitat and passive recreational facilities at Barker Slough, creation of an upland recreation area in the South Delta, possibly in the Old River area, development of floating campsites/day use areas and expanded waterfowl hunting programs (boat-in and longer-term), and potentially increasing the recreational use of SWP facilities.

There are a number of boater education programs that provide information on boating safety, proper disposal of hazardous wastes, and proper sewage handling facilities, but their effectiveness is uncertain. Although there are numerous pumpout and restroom facilities located throughout the Delta, it is uncertain how frequently they are used.

Vessel abandonment is a significant problem in the Delta which has direct impacts on source water quality. There are three key state programs that address the issue of abandoned vessels; however, two of these programs require local agencies to provide ten percent matching funds. Many local agencies cannot provide the matching funds due to budget constraints.

KEY WATER QUALITY VULNERABILITIES OF THE STATE WATER PROJECT

Chapter 14 contains a discussion of the key water quality vulnerabilities of the SWP. The CDPH, SWP Contractors, and DWR identified the SWP vulnerabilities to be addressed in the 2011 Update. The key findings for each of the specific topics discussed in Chapter 14 are presented in this section.

NORTH BAY AQUEDUCT

The NBA Contractors have taken a multifaceted approach to improving the quality of water delivered to their customers. They have conducted studies in conjunction with MWQI on the water quality of the Barker Slough watershed, installed real-time monitoring equipment to provide advanced warning of water quality problems, installed fencing and alternative water supplies to exclude cattle from Barker Slough, evaluated the impacts of Campbell Lake operations on Barker Slough water quality, and conducted hydrodynamic modeling of the watershed to better understand the sources of water at the Barker Slough watershed under varying hydrologic conditions. In addition, the NBA Contractors evaluated treatment options and water exchanges as methods of improving water quality. The NBA Contractors are currently pursuing an alternate intake on the Sacramento River. The alternate intake would be operated in conjunction with the existing intake at Barker Slough to provide operational flexibility and improve water quality.

CLIFTON COURT FOREBAY

While developing the scope of work for the 2006 Update, the SBA Contractors expressed concerns that sedimentation of Clifton Court Forebay has resulted in a shallow water body that encourages algal and vascular plant growth that result in T&O problems. The 2006 Update contains an analysis of real-time water quality monitoring data that could potentially be used to detect algal blooms. The scope of work for the 2011 Update did not include any further analysis of the impact of sedimentation in Clifton Court on algal growth and T&O problems or of the ability of monitoring equipment to detect algal blooms. The status of action items from the 2006 Update was reviewed.

SOUTH BAY AQUEDUCT

The SBA Contractors have engaged in a number of activities to improve water supply reliability and water quality of the SBA. The SBA Improvement and Enlargement Program is nearing completion. The Watershed Protection Program Plan was completed in 2008 and the SBA Contractors conducted several workshops and developed public education materials on protecting drinking water quality in Bethany Reservoir and Lake Del Valle. The SBA Contractors previously expressed concern over a proposed trail along the SBA but that project does not currently have funding and appears to not be of any immediate concern.

Cattle grazing in the Bethany Reservoir watershed remains a major concern. DWR leases a 115-acre parcel on the southwestern shoreline that drains to Bethany Reservoir and two parcels on the northeast side, most of which do not drain to the reservoir. The leases require that good grazing practices be used so the property is not over-grazed and allow DWR to inspect the property to

determine if the land is being over-grazed. The leases also require that fences be constructed and maintained to prevent cattle from entering the property of adjacent property owners but there are no requirements for fencing to keep cattle out of Bethany Reservoir. Stormwater monitoring conducted by the SBA Contractors showed that the Bethany Headlands drainage on the western side of Bethany Reservoir contained high levels of *Giardia* and *Cryptosporidium* relative to other sources of water to the SBA. Cattle are the likely source of these pathogens because cattle grazing is the primary use of this land and cattle are known carriers of these pathogens.

DELTA-MENDOTA CANAL/CALIFORNIA AQUEDUCT INTERTIE

Construction was completed on an intertie between the California Aqueduct and the DMC in April 2012. The intertie will allow water pumped at the Jones Pumping Plant to be conveyed in the California Aqueduct to O'Neill Forebay. The Central Valley Project (CVP) water reaching O'Neill Forebay may be pumped into San Luis Reservoir, released to the San Luis Canal and the Dos Amigos Pumping Plant, or released through the O'Neill Pump-Generating Plant to the lower DMC and Mendota Pool.

The Final EIS did not evaluate the impacts on the quality of water in the California Aqueduct, O'Neill Forebay, or San Luis Reservoir as a result of the intertie. The intertie will be operated mainly between September and March when EC levels and bromide concentrations are highest in the South Delta. However, the volume of water pumped from the DMC into the California Aqueduct (maximum of 467 cubic feet per second) is relatively small compared to the flows in the California Aqueduct so there may not be a change in EC or bromide levels.

SAN LUIS RESERVOIR

The U.S. Bureau of Reclamation (Reclamation), Santa Clara Valley Water District, and San Luis and Delta-Mendota Water Authority have conducted a number of studies and held public scoping meetings for the San Luis Low Point Improvement Project. The three agencies are currently preparing a Feasibility Report and companion EIS/EIR which will present three alternatives: 1) Lower San Felipe Intake Comprehensive Plan, 2) Pacheco Reservoir Comprehensive Plan, and 3) the Combination Comprehensive Plan. It is anticipated that the Feasibility Report and Draft EIS/EIR will be completed in July 2012 and the Final EIS/EIR will be completed in January 2013.

The State Water Project Contractors Authority, MWQI, and O&M are currently addressing cattle grazing in the Cottonwood Bay area of the San Luis Reservoir. Efforts are underway to coordinate among the cattle owner, the land owner (Reclamation) and the San Luis Field Division to prevent the cattle from accessing the water.

COASTAL BRANCH

Over the last five years, the Central Coast Water Authority (CCWA) has implemented a number of measures to address T&O issues that may be attributed to sediment accumulation in the Coastal Branch forebays and canals. These measures include: 1) cooperating with and encouraging O&M to implement a routine sediment removal program from the open channel canal, forebays, and storage tanks, 2) implementing an MIB Monitoring Program/Response Plan

at the Polonio Pass Water Treatment Plant (PPWTP) influent; Devil's Den, Bluestone, and Polonio Pass pumping plant forebays; and selected canal locations, 3) conducting an experiment using the SolarBee to evaluate its effectiveness in minimizing sediment accumulation and prevention of blue-green algae blooms in a pumping plant forebay, and 4) investigating alternative theories that may explain the high MIB levels.

Sediment accumulation in the pumping plant forebays is still occurring and remains a concern despite an active sediment removal program developed by O&M. In addition, elevated ammonia levels are routinely observed in the PPWTP influent just prior to the O&M annual winter shutdown, as water levels in the canal are reduced.

Through the examination of sediment removal records and water quality sampling along the Coastal Branch over the past five years, CCWA staff has not been able to confirm that greater amounts of sediment will lead to greater T&O incidents. However, there have been no major sustained T&O incidents from 2006 to 2010 at either Banks or the PPWTP.

NON-PROJECT INFLOWS

Non-Project inflows introduced into the California Aqueduct totaled 1,490,164 acre-feet from 2006 to 2010, which is a substantial increase from the 360,000 acre-feet previously introduced from 2001 to 2005. During certain months in the 2006 to 2010 period, inflows contributed a substantial percentage of the aqueduct flow. In February 2009, inflows contributed 87 percent of the flow at Check 29, and 92 percent of the flow at Check 41. This is an increase over the 2001 to 2005 period, as the highest monthly percentage at Check 41 was 40 percent.

Groundwater quality data from the resultant blend of participating wells for each project proponent, prior to entering the California Aqueduct, were examined. Based on the available data, Semitropic Water Storage District (Semitropic) inflows had the highest arsenic concentrations, with the majority of samples exceeding the drinking water MCL of 10 µg/L. Although conditions were placed on Semitropic's 2007 project proposal to "attempt to achieve an arsenic concentration of 10 µg/L or less in its pump-in water through full use of its resources," this was not achieved. Although one of the conditions placed on Semitropic is stated as above, it should be noted that the Semitropic inflow was actually evaluated as one component of the Kern program that also included Kern Water Bank, Kern County Water Agency, and the Wheeler Ridge-Maricopa Water Storage District. As such, the weighted average of all of the Kern program inflows was evaluated by the Facilitation Group and could not exceed any drinking water MCLs. Therefore, Semitropic was allowed to pump-in water with arsenic concentrations greater than 10 µg/L as long as the weighted average of other Kern inflows and Semitropic inflows was less than 10 µg/L. Semitropic also had the highest medians for bromide, total dissolved solids (TDS), and sulfate. The highest median for nitrate (10.3 mg/L) was measured at the Arvin-Edison Water Storage District inflow location, but it was well below the MCL of 45 mg/L.

Modeling results from the Kern County Water Agency Aqueduct Blending Model were also compared to grab samples taken along the aqueduct. The model predicts arsenic, DOC, and TDS concentrations fairly close to measured water quality at Check 29 and Check 41. The model

tends to predict lower bromide concentrations and higher chromium and nitrate concentrations compared to measured water quality at both Check 29 and Check 41. This is because modeled results use long-term averages as the background concentrations at O'Neill Forebay Outlet, yet the actual water quality at this location may vary higher or lower from the long-term average. Overall, the Aqueduct Blending Model has become a useful tool in managing the non-Project inflows and assessing downstream water quality impacts.

The introduction of non-Project inflows has generally decreased the concentrations of bromide and DOC and increased the concentrations of nitrate and arsenic in the California Aqueduct downstream of the inflows. Specifically, there were eleven months when arsenic levels were measured at or above 5 µg/L at Check 29 and Check 41. Notably, arsenic levels were 6 µg/L for two consecutive months in February and March 2009 at Check 41. The percent of inflow volumes was high during this time period, averaging 83 percent in January 2009, 92 percent in February 2009, and 68 percent in March 2009. In addition, there were six non-consecutive months when the change in arsenic concentration from upstream to downstream of the Semitropic inflows was greater than 2 µg/L. This is notable as one of the conditions placed on Semitropic in 2007 was "Semitropic will operate its inflow program to achieve an increase in downstream arsenic concentrations of no more than 2 µg/L over background levels in the California Aqueduct." Further information is provided in Chapter 14. Only slight changes were observed for TDS and sulfate.

Semitropic constructed a demonstration facility to remove arsenic from groundwater. The demonstration facility was operated from November 2007 to November 2009 and treated a total of 61,665 acre-feet at a cost of \$1.8 million.

Westlands was approved to convey their groundwater on a one-time basis from June to September 2008 by a Governor's Executive Order addressing the drought. During this period, Westlands pumped 12,581 acre-feet of groundwater into the San Luis Canal portion of the California Aqueduct. The Governor's Executive Order bypassed water quality testing requirements that were specified in the contract between DWR and Westlands, so Westlands was allowed to begin pumping groundwater prior to any evaluation. According to DWR, two wells were shut down based on high levels of TDS and sulfate found after the wells were placed into service. Therefore, some unacceptable water was introduced into the San Luis Canal portion of the California Aqueduct during this four-month period.

SUBSIDENCE ALONG THE AQUEDUCT

There has been renewed interest in subsidence in the San Joaquin Valley due to increased groundwater pumping, caused by a reduction of available imported surface water deliveries due to drought and fish-protection measures. In 2007, there was a 150 foot decline in groundwater elevation, which caused subsidence. Damage to the SWP due to subsidence has occurred at the turnout structures, check sites, canal lining, and bridges. The worst subsidence damage has occurred within the jurisdiction of the San Luis Field Division near Coalinga.

USGS is currently conducting a study on behalf of DWR to better understand the occurrence of land subsidence along the California Aqueduct. The study is focused on the Westlands area and will determine the location and extent of changes in land surface elevation along the California

Aqueduct. A similar study is being conducted for the CVP, and both projects are expected to be completed in September 2012. USGS hopes to define a groundwater level that will prevent/manage future subsidence.

PYRAMID LAKE

Pacific Pipeline Systems LLC (responsible party) has completed repairs and relocations of Line 63 which was damaged and resulted in a March 2005 oil spill. They have increased ground and aerial inspection of the pipeline after rain events, and conducted emergency training exercises. Pacific Pipeline Systems was also required to pay a \$1.3 million civil penalty and is currently completing additional specific actions to relocate or improve resistance to movement for Line 63.

The Upper Piru Creek portion of the Pyramid Lake watershed was impacted by the Day Fire which began on September 4, 2006 and was contained on October 2, 2006. The majority of the burn area tributary to Pyramid Lake burned at a low intensity. Although sediment loading and runoff was predicted to increase post-fire, ash and debris flow did not occur due to moderate rains that winter. According to MWDSC staff, there were no changes to influent water quality at the Jensen Water Treatment Plant as a result of the fire.

CASTAIC LAKE

MWDSC has completed necessary best management practices to discourage gull roosting on the lake. Two pilot scale gull management exercises were conducted in 2007 with limited success. A brochure was developed by MWDSC and distributed at the Castaic Lake Recreation Area to discourage gull feeding by the general public. Monthly average *E. coli* levels at the Jensen Water Treatment Plant have declined since 2002.

On April 22, 2008, a 5,000 gallon sewage spill originated from the Warm Springs Rehabilitation Center in Castaic, California. The wastewater pump station experienced an electrical failure and wastewater spilled in front of the pump station. The Los Angeles County Health Department determined that the sewage did not enter Castaic Lake or any tributaries to the lake. *Cryptosporidium* and *Giardia* were not detected in samples collected by MWDSC and *E. coli* and fecal coliforms were either not detected or were present at low levels in samples analyzed by Castaic Lake Water Agency.

HESPERIA MASTER DRAINAGE PLAN

Urban runoff from the City of Hesperia is discharged to the California Aqueduct through 45 drop inlets. This issue was identified in the 1990 SWP Watershed Sanitary Survey and has still not been resolved. The San Bernardino County Flood Control District has developed a plan to address local drainage concerns but does not plan to address the discharge of urban runoff into the aqueduct unless DWR agrees to help fund the project.

Continuous turbidity and EC data measured at Check 66, which is downstream of the City of Hesperia, were analyzed to determine if levels increased during periods of heavy rainfall. Based on the current amount of development in the watershed, flow through the drop inlets is likely impacting downstream water quality only under extreme storm conditions.

SILVERWOOD LAKE

There were no incidents such as wastewater spills, sewer line breakages, fires, or high runoff events in the Silverwood Lake watershed during the study period. There were no high turbidity events in the source water, with the exception of one day in January 2006, and three days in January 2010 when turbidities reached 20 NTU. Other than these two time periods, turbidity was less than 10 NTU.

LAKE PERRIS

Since the 2006 Update was completed, use of Lake Perris by MWDSC has been reduced due to regulatory restrictions on pumping from the Delta and limitations to protect recreation and endangered species due to the Lake Perris drawdown. Lake Perris has been lowered by 25 feet below the normal maximum level to mitigate seismic risk while a permanent solution is being determined by DWR. Although MWDSC was proceeding with the procurement of a hypolimnetic oxygenation system and the design of voluntary swimming alternatives (i.e. swim lagoons, water play areas and other water features), MWDSC does not currently view Lake Perris as a reliable enough source of SWP supply to justify the cost to construct these facilities. As such, MWDSC has discontinued their efforts to implement these projects.

In January 2010, DWR prepared a Draft EIR for the Perris Dam Remediation Program to address seismic hazard. The Draft EIR evaluated the following dam remediation alternatives: 1) increased dam capacity alternative (above 1,588 feet), 2) normal dam capacity (at 1,588 feet), 3) reduced dam capacity alternative (at 1,563 feet), 4) recreation alternative (at 1,542 feet), 5) dam decommissioning alternative (draining the lake), and 6) no project alternative. The Final EIR was completed in September 2011. In the Final EIR, DWR concluded that the recreation alternative is the environmentally superior dam remediation alternative.

MWDSC, Coachella Valley Water District, and Desert Water Agency submitted comment letters on the Draft EIR, and commented that there was an inadequate range of alternatives considered, and that a more detailed analysis of possible alternatives should have been conducted. These agencies are in the process of reviewing the Final EIR.

Recreational attendance at the Lake Perris State Recreation Area has declined since the drawdown of the lake in 2005. However, attendance increased by 40,000 visitors from 2010 to 2011. The maximum number of allowable boats on the lake has been reduced from 500 to 250 for safety reasons. There were eleven beach closures from 2005 to 2010 due to *E. coli* levels exceeding standards for recreational usage.

STATE WATER PROJECT FACILITY OPERATIONS VULNERABILITIES

Chapter 15 contains a discussion of the key operational vulnerabilities of the SWP. The CDPH, SWP Contractors, and DWR identified the operational vulnerabilities to be addressed in the 2011 Update. The key findings for each of the specific topics discussed in Chapter 15 are presented in this section.

BIOLOGICAL OPINIONS

Both the USFWS and NMFS biological opinions require exports to be limited to reduce reverse flows in the Old and Middle rivers between December and June. The intent of this action is to prevent entrainment of delta smelt at the export pumps. The other action with the potential to impact water quality is the requirement to increase Delta outflow in wet and above normal years during the fall months to move the low salinity zone near Suisun Marsh, which is thought to improve delta smelt survival. While modeling studies have been conducted to examine the impacts of the biological opinions on water supply, there have not been any modeling studies to evaluate the impacts on drinking water quality. The impacts of the Wanger Interim Remedial Order on drinking water quality were modeled. Historical data were examined and the results of the modeling studies on the Wanger Interim Remedial Order were reviewed in an attempt to determine if any conclusions could be drawn on the likely impacts of the biological opinions. Delta hydrology is extremely variable, Delta operations are highly complex, and the operations rules to comply with the actions in the biological opinions will change the way the Delta has historically been operated. It is not possible to reach firm conclusions on the impacts of the biological opinions without conducting modeling studies; however, it appears that the greater influence of the San Joaquin River during the periods that Old River and Middle River reverse flows are regulated will result in higher levels of TOC, DOC, EC, and bromide at the south Delta pumping plants. Shifting exports to the July to September period may result in more water with lower TOC and possibly EC being exported. Bromide concentrations may be lower in July but would increase to high levels by September. Increased fall Delta outflow, in the range that would likely occur in September, does not appear to have any impact on drinking water quality at the pumping plants.

HEAD OF OLD RIVER BARRIER

The head of Old River barrier (HORB) is installed to keep migrating salmon in the San Joaquin River and to prevent them from entering the Old River and being drawn towards agricultural diversions and the south Delta pumping plants. Historically the HORB was a 200-foot long barrier constructed by placing rock in the main channel bed along with overflow weirs and gated culverts. The physical barrier effectively blocks most flow from the San Joaquin River into the Old River. As a result of the delta smelt biological opinion, participants in the Vernalis Adaptive Management Plan suggested testing a non-physical barrier as an alternative to the rock barrier, since the physical barrier may have adverse impacts on delta smelt. A non-physical barrier was installed in the Old River in the spring of 2009 as an experimental project to determine if migrating salmon and steelhead would avoid the barrier and stay in the San Joaquin River rather than entering the Old River.

Modeling studies using the Delta Simulation Model 2 (DSM2) have shown that the physical barrier prevents the San Joaquin River from entering the Old River when it is in place. There have not been any studies on the impacts on water quality of replacing the physical barrier with a non-physical barrier. It would seem logical that the San Joaquin River would have a greater influence on water quality at the south Delta pumping plants with a non-physical barrier. Water quality data were compared for two relatively dry periods: 2002 to 2004 when the physical barrier was in place and 2008 to 2010 when there was no physical barrier. The Delta

hydrodynamics are too complex to draw any conclusions from the examination of these limited data.

IMPACTS OF DROUGHT ON WATER QUALITY

The water quality impacts of dry years at the Barker Slough and Banks Pumping Plants were evaluated. These two locations were selected because they reflect the quality of water pumped from the north and south Delta in different year types.

When examined on a monthly basis, there are few significant differences between wet and dry year monthly medians at Barker Slough for TOC, bromide, and nutrients. During dry years, EC levels are higher during the wet months of January through April and turbidity levels are lower during the December to April period.

When examined on a monthly basis, the substantial impact of dry years on EC and bromide is evident at Banks. During dry years, EC and bromide are statistically significantly higher in the summer months, when exports are highest, and in the winter months. Turbidity levels are statistically significantly lower during the summer months of dry years. TOC concentrations are higher during a few months of dry years and lower during other months, with no clear pattern. Nutrient concentrations are not significantly different between dry years and wet years.

FINDINGS AND RECOMMENDATIONS

Chapter 16 contains a discussion of the key findings from the System Environment, Water Quality, and Vulnerabilities chapters. The recommendations presented in this chapter are draft potential actions for consideration by the SWP Contractors, CDPH and the DWR MWQI Program and O&M Division. These agencies will work with the consulting team to rank the draft recommendations and determine if, and how, they will be implemented. An Action Plan will be developed by September 2012 that describes each action in more detail, identifies the responsible entity, and lays out the schedule for implementation.

STATE WATER RESOURCES CONTROL BOARD

RESOLUTION NO. 68-16

STATEMENT OF POLICY WITH RESPECT TO
MAINTAINING HIGH QUALITY OF WATERS IN CALIFORNIA

WHEREAS the California Legislature has declared that it is the policy of the State that the granting of permits and licenses for unappropriated water and the disposal of wastes into the waters of the State shall be so regulated as to achieve highest water quality consistent with maximum benefit to the people of the State and shall be controlled so as to promote the peace, health, safety and welfare of the people of the State; and

WHEREAS water quality control policies have been and are being adopted for waters of the State; and

WHEREAS the quality of some waters of the State is higher than that established by the adopted policies and it is the intent and purpose of this Board that such higher quality shall be maintained to the maximum extent possible consistent with the declaration of the Legislature;

NOW, THEREFORE, BE IT RESOLVED:

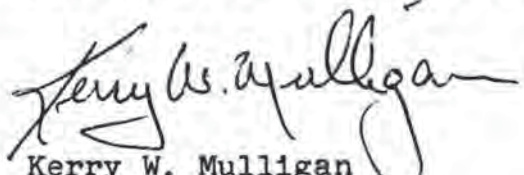
1. Whenever the existing quality of water is better than the quality established in policies as of the date on which such policies become effective, such existing high quality will be maintained until it has been demonstrated to the State that any change will be consistent with maximum benefit to the people of the State, will not unreasonably affect present and anticipated beneficial use of such water and will not result in water quality less than that prescribed in the policies.
2. Any activity which produces or may produce a waste or increased volume or concentration of waste and which discharges or proposes to discharge to existing high quality waters will be required to meet waste discharge requirements which will result in the best practicable treatment or control of the discharge necessary to assure that (a) a pollution or nuisance will not occur and (b) the highest water quality consistent with maximum benefit to the people of the State will be maintained.
3. In implementing this policy, the Secretary of the Interior will be kept advised and will be provided with such information as he will need to discharge his responsibilities under the Federal Water Pollution Control Act.

BE IT FURTHER RESOLVED that a copy of this resolution be forwarded to the Secretary of the Interior as part of California's water quality control policy submission.

CERTIFICATION

The undersigned, Executive Officer of the State Water Resources Control Board, does hereby certify that the foregoing is a full, true, and correct copy of a resolution duly and regularly adopted at a meeting of the State Water Resources Control Board held on October 24, 1968.

Dated: October 28, 1968


Kerry W. Mulligan
Executive Officer
State Water Resources
Control Board

STATE OF CALIFORNIA
STATE WATER RESOURCES CONTROL BOARD

ORDER WRO 2004-0043-EXEC

In the Matter of the Approval of the Water Quality Response Plan

Under SWRCB Decision 1641

Submitted by

DEPARTMENT OF WATER RESOURCES

and

UNITED STATES BUREAU OF RECLAMATION

ORDER DENYING RECONSIDERATION AND AMENDING CONDITION

BY THE EXECUTIVE DIRECTOR¹:

1.0 INTRODUCTION

This Order denies reconsideration of a decision in a letter dated July 28, 2004 from the Chief of the Division of Water Rights (Division), and amends a condition in the letter. The July 28, 2004 letter temporarily and conditionally approves the water quality response plan (WQRP) that the Department of Water Resources (DWR) and the U.S. Bureau of Reclamation (USBR) submitted to the Division on July 1, 2004. The temporary approval is set to expire on August 1, 2005.

The DWR and the USBR jointly petition the State Water Resources Control Board (SWRCB) for reconsideration of the Division Chief's conditional temporary approval of their proposed WQRP for operation of the Joint Points of Diversion (JPOD) under Stage 1 and Stage 2. The WQRP is

¹ SWRCB Resolution No. 2002 - 0104 delegates to the Executive Director the authority to supervise the activities of the SWRCB. Unless a petition for reconsideration raises matters that the SWRCB wishes to address or requires an evidentiary hearing before the SWRCB, the Executive Director's consideration of petitions for reconsideration of actions taken by a Division Chief falls within the scope of the authority delegated under Resolution No. 2002 - 0104. Accordingly, the Executive Director has the authority to deny a petition for reconsideration or set aside or modify the Division Chief's action.

required in SWRCB Decision 1641 (D-1641) as a condition of the JPOD, under which the DWR and the USBR are authorized to use each other's points of diversion and redirection in the southern Delta. In condition 5 on pages 150-151 and in condition 5 on page 156, D-1641 requires the DWR and the USBR to develop a response plan with input from Contra Costa Water District (CCWD) that is acceptable to the Division Chief. The conditions of D-1641 require that the plan "ensure that the water quality in the southern and central Delta will not be significantly degraded through operations of the Joint Points of Diversion to the injury of water users in the southern and central Delta."

2.0 GROUND FOR RECONSIDERATION

The SWRCB may order reconsideration of all or part of a decision or order adopted by the SWRCB. (Wat. Code, § 1122.) California Code of Regulations, title 23, section 768 provides that a petition for reconsideration may be based upon any of the following causes:²

- (a) Irregularity in the proceedings, or any ruling, or abuse of discretion, by which the person was prevented from having a fair hearing;
- (b) The decision or order is not supported by substantial evidence;
- (c) There is relevant evidence that, in the exercise of reasonable diligence, could not have been produced;
- (d) Error in law.

DWR and USBR raise issues that implicate the causes listed in section 768, subdivision (d). To the extent that this order does not address all of the issues raised in the petition for reconsideration, either these issues are insubstantial or DWR and USBR failed to meet the requirements for a petition for reconsideration under the SWRCB's regulations. (*Id.* §§ 768-769.)

3.0 BACKGROUND

² All further regulatory references are to the SWRCB's regulations located in title 23 of the California Code of Regulations unless otherwise indicated.

In D-1641, the SWRCB authorized the DWR and the USBR to use the JPOD. The JPOD authorization includes three stages. The three stages correspond to export rates and the purposes
 ///

for which the DWR and the USBR are authorized to divert or redivert water under the JPOD.³ Each stage of the authorization is subject to special terms and conditions to mitigate the effects of using the JPOD. Additionally, all stages are subject to five terms and conditions, one of which is the requirement for a WQRP. The condition provides:

“Permittee shall develop a response plan to ensure that the water quality in the southern and central Delta will not be significantly degraded through operations of the Joint Points of Diversion to the injury of water users in the southern and central Delta. Such a plan shall be prepared with input from the designated representative of the Contra Costa Water District and approved by the Chief, Division of Water Rights.”

In Order WR 2000-02, the SWRCB added this condition to the approval of the JPOD in response to a petition by CCWD for reconsideration of D-1641. CCWD had expressed concern that the JPOD could cause the salinity at CCWD’s intakes on the Contra Costa Canal or at Old River to increase significantly.

The Division Chief conditionally approved the WQRP after having rejected an earlier version due to lack of technical information concerning the potential impacts on water quality caused by JPOD operations. Because there was remaining uncertainty regarding water quality impacts to members of the South Delta Water Agency, however, the Division Chief approved the WQRP only temporarily, until August 1, 2005.

³ The USBR is the primary user of JPOD due to limitations on the capacity of its facilities at the Tracy Pumping Plant. Under Stage 1, the USBR can use the DWR’s point of diversion at Banks Pumping Plant to serve the Cross Valley Canal contractors and Musco Olive, to support a recirculation study, and to recover export reductions taken to benefit fish. Under Stage 2, the USBR can use the Banks Pumping Plant for any purpose authorized under its permits, except that the total pumping at Banks cannot exceed the limits of the U.S. Army Corps of Engineers permit. Under Stage 3, the USBR can use the Banks Pumping Plant up to the physical capacity of the pumping plants, subject to the completion of certain mitigation measures.

4.0 THE PETITION FOR RECONSIDERATION

The DWR and the USBR seek two changes in the approval of the WQRP: (1) that condition 2 of the approval be deleted or revised and (2) that the approval be made permanent, not temporary.

4.1 The Parties' Positions

Condition 2 of the approval requires that the DWR and the USBR model the effects on water quality at CCWD's intakes prior to commencing JPOD diversions during excess conditions when CCWD is authorized to divert water under its Los Vaqueros water rights. The DWR and the USBR state that they did not include this type of modeling in the plan because they concluded that the "JPOD would not cause significant degradation in water quality resulting in injury to CCWD because the water will be usable for the purposes of use identified in CCWD's water right permit." This conclusion is based on their modeling analyses of JPOD operations that they submitted with the WQRP. In most cases, the modeling analyses show that water quality conditions under D-1641 with JPOD will be better than water quality conditions under D-1485 without JPOD. In all cases, the modeling analyses show that the salinity level with JPOD will remain well below the water quality objectives for municipal and industrial uses required in D-1641.

The DWR and the USBR argue, in effect, that it would be illegal and unconstitutional to require them to maintain water quality better than the salinity objectives in the 1995 Bay-Delta water quality control plan when they use the JPOD. They cite as authority *Meridian, Ltd. v. City and County of San Francisco* (1939) 13 Cal.2d 424, 90 P.2d 537 and *Town of Antioch v. Williams Irrigation District* (1922) 188 Cal. 451, 205 P. 688. In each case, the court decided that the protection due to a downstream senior water right holder when an upstream junior appropriator's diversions impacted the quality of water available to the senior water right holder was less than the full amount claimed by the downstream senior water right holder. Based on these cases, the DWR and the USBR argue that if the water at CCWD's intakes meets the 250 milligrams per liter chloride objective, the water is useable as a matter of law and they should not have to do further analysis to determine whether the JPOD will cause a significant degradation of the water quality in the southern and central Delta due to operation of the JPOD.

As an alternative to deleting condition 2, the DWR and the USBR argue that the SWRCB should modify the condition. They state that they cannot practically conduct water quality modeling that would determine the annual average potential changes in water quality as required by condition 2. Instead, they say that they could provide forecasts by modeling of short-term water quality conditions during excess conditions.

In response to the joint petition for reconsideration, CCWD argues that the SWRCB's anti-degradation policy in SWRCB Resolution 68-16 would be violated if the JPOD were allowed to cause the chloride level to increase up to the maximum level under the objective. Resolution 68-16 provides, in substance, that whenever the existing quality of water is better than the quality established in water quality objectives, the existing high quality will be maintained unless it is demonstrated that a change will be consistent with maximum benefit to the people of the state, will not unreasonably affect the beneficial use of the water, and will meet the water quality objectives. CCWD cites with approval the Division Chief's statement that "significant degradation of water quality may occur in the absence of violation of water quality objectives in cases where the degradation impairs a senior water right of water of a usable quality." CCWD also argues that if there were a significant degradation of its water quality due to JPOD operations, mitigation would be required under the California Environmental Quality Act. CCWD points out that much has changed since the two court decisions relied upon by DWR and USBR, including more information, statutory changes, and further court decisions more directly focused on the unique problems presented in the Delta. In consequence, CCWD suggests that given these changes, the *Antioch* decision in particular might have been decided differently under the current circumstances. CCWD also argues that in any event, the two cases are not directly on point because the current situation does not involve an upstream diversion of water. Finally, CCWD supports the requirement that the DWR and the USBR provide additional information in order to evaluate whether degradation of water quality due to JPOD is significant.

4.2 Discussion

Although the DWR and the USBR characterize condition 2 of the WQRP approval as a legal issue, and CCWD relies on legal arguments to respond to the DWR and the USBR, condition 2

of the WQRP approval is based on a need for more factual information.⁴ The purpose of condition 2 of the WQRP approval is to require more information in advance of a planned JPOD operation so that the Division Chief can make a factual determination, if necessary, as to whether the condition in D-1641 is satisfied. The determination of whether water quality will be significantly degraded through operation of the JPOD at a particular time will depend on the facts presented. Such determination may also vary based on factors both within and outside the southern and central Delta, including treatment requirements, public health concerns, and the effect on water supplies and water quality available to other users taking water either directly from the Delta or from water suppliers in distant locations.⁵ This determination need not be based on a statistical expression of significance.

The modeling required by condition 2 is intended to supply some of the necessary information. The condition requires modeling of the potential annual average change in water quality. The DWR and the USBR now request that if condition 2 is retained, it should instead require modeling that will forecast water quality on a short-term basis in the southern Delta. The Division did not require this type of modeling because the Division believed that the DWR and the USBR did not have the means to provide forecasts by modeling short-term water quality changes during excess conditions. Modeling to obtain short-term forecasts of water quality will provide a more accurate assessment of the immediate effects of using the JPOD, but in some cases it could give the appearance of an overall annual degradation when in fact there is an overall annual improvement in water quality. Since the DWR and the USBR can provide the short-term modeling and are willing to do so, I will modify condition 2 to require modeling that forecasts water quality on a short-term basis.

⁴ In part, the DWR/USBR legal arguments are an attack on the inclusion of the condition in revised D-1641 requiring a water quality response plan. The DWR and the USBR did not object to this condition when it was proposed, however, and did not challenge it in court. It is now too late to challenge the inclusion of that condition. (See Wat. Code, § 1126, subd. (b).) When the SWRCB gets the facts it needs, it will be in a better position to interpret the condition in light of the actual factual context.

⁵ This determination will require a balancing. The SWRCB recognizes that the amount of water available for diversion from the Delta is directly related to the quality of the water maintained in the Delta, that the water supplies available to the DWR and the USBR are limited, and that there is a great demand for water supplies.

The DWR and the USBR also seek to have the SWRCB change the requirement in D-1641 from a requirement that the water quality in the southern and central Delta not be significantly degraded by JPOD operations to a requirement that the water quality in the Delta be fit for the uses for which the water users taking water from the Delta divert it. The DWR and the USBR would further define water as being fit for use by the water user if the water meets the water quality objective for that beneficial use.⁶ In D-1641, the SWRCB adopted the requirement that the JPOD not significantly degrade the water quality. I will not change this requirement. If the DWR and the USBR want to seek a change in a condition imposed on their permits and licenses in D-1641, they must file a petition for a change in their water right permits and licenses.

Additionally, the WQRP temporary approval requires, in condition 3, additional information regarding the potential water quality impacts to southern Delta diverters related to Stage 1 and Stage 2 JPOD diversions. The DWR and the USBR do not directly address this requirement, but they request that the WQRP approval be made permanent. Making the approval permanent at this time would nullify the requirement in condition 3. To allow time for condition 3 to be satisfied, I will not make the approval permanent at this time.

5.0 CONCLUSION

1. The petition for reconsideration should be denied.
2. Condition 2 of the July 28, 2004 approval should be revised to provide for short-term forecasting of water quality in the central and southern Delta.
3. The approval of the WQRP should remain temporary.

///

///

///

⁶ Depending on the facts, this proposed definition could be circular. The requirement in SWRCB Resolution No. 68-16 to maintain the existing high quality of water unless a change (1) is consistent with maximum benefit to the people of the state, (2) will not unreasonably affect the beneficial use of the water, and (3) will meet the water quality objectives is itself a water quality objective. (See SWRCB Order WQ 86-17 at 17 [“Resolution 68-16 has been adopted, as a general water quality objective, in all . . . regional water quality control plans.”].) Accordingly, allowing the water quality to be degraded until it barely meets the numerical objective could violate this objective.

ORDER

IT IS HEREBY ORDERED THAT the petition for reconsideration is denied, and condition 2 of the July 28, 2004, temporary approval is amended as follows:

“Prior to commencing JPOD diversions during excess conditions when CCWD is authorized to divert water under its Los Vaqueros water rights, DWR and USBR shall conduct water quality modeling ~~to determine annual average potential changes in water quality at CCWD’s intakes associated with planned JPOD diversions in comparison to conditions that would have existed under D-1485 conditions~~ that will forecast water quality on a short-term basis in the southern Delta near CCWD’s intakes associated with planned JPOD diversions. ~~If modeling indicates that there may be an annual average increase in chloride levels as a result of JPOD operations, DWR and USBR shall consult with CCWD to determine whether an agreement may be reached regarding JPOD diversions.~~ DWR and USBR shall submit results of the modeling forecasts to CCWD and the SWRCB. If CCWD objects to the planned JPOD diversions, and the Projects and CCWD are unable to agree on operations of JPOD, the Projects shall contact the Chief of the Division for a determination regarding required mitigation, if any, for potential water quality impacts associated with JPOD operations. In order to substantiate an allegation of potential harm to its use of water, CCWD should submit detailed information concerning how the change in chloride levels would impact CCWD’s operations (including potential health concerns, treatment costs, blending ability, and availability of water to meet environmental and customer demands).”

Except as modified herein, all conditions of the July 28, 2004 temporary approval remain in effect.

Dated: October 22, 2004

ORIGINAL SIGNED BY HARRY M. SCHUELLER for
Celeste Cantú
Executive Director

STATE OF CALIFORNIA
CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY
STATE WATER RESOURCES CONTROL BOARD

DIVISION OF WATER RIGHTS

PERMIT FOR DIVERSION AND USE OF WATER

AMENDED PERMIT 20749

Application 20245 of

Contra Costa Water District
P.O. Box H2O
Concord, CA 94524

filed on **June 5, 1961**, has been approved by the State Water Resources Control Board (State Water Board or Board) SUBJECT TO PRIOR RIGHTS and to the limitations and conditions of this permit.

Permittee is hereby authorized to divert and use water as follows:

1. Source of water

Source:

Tributary to:

(1) Old River

San Joaquin Delta Channels

(2) Victoria Canal

Old River thence

San Joaquin Delta Channels

within the Counties of **Contra Costa** and **San Joaquin**.

2. Location of points of diversion and redirection

By California Coordinate System of 1983 in Zone 3	40-acre subdivision of public land survey or projection thereof	Projected Section	Township	Range	Base and Meridian
(1) Old River Intake North 2,147,455 feet and East 6,250,918 feet	NW ¼ of SE ¼	31	1N	4E	MD
(2) Victoria Canal Intake North 2,139,610 feet and East 6,259,970 feet	NE ¼ of NW ¼	9	1S	4E	MD
Point of Rediversion Los Vaqueros Dam North 2,129,559 feet and East 6,207,039 feet	NW ¼ of NW ¼	23	1S	2E	MD

3. Purpose of use	4. Place of use	Section	Township	Range	Base and Meridian	Acres
Incidental Fish and Wildlife Preservation and/or Enhancement						
Water Quality						
Recreation						
Domestic						
Municipal						
Industrial						
Irrigation	Contra Costa Water District, Pittsburg, Antioch, Brentwood, Oakley, Los Vaqueros recreation area, and rural county subarea		2S 1S 1N 2N 3N	3W 2W 1W 1E 2E 3E 4E	MD	931
Incidental Hydroelectric Power Generation	Los Vaqueros Pipeline Energy Recovery facility within NW ¼ of NW ¼ of	34	2N	2E	MD	

The place of use is shown on maps filed with the State Water Board.

The following list of acronyms shall be added to Permit 20749:

- Department of Fish and Game - DFG
- National Marine Fisheries Service – NMFS
- Alternate Intake Project – AIP
- U.S. Fish and Wildlife Service – USFWS
- Department of Water Resources – DWR
- U.S. Bureau of Reclamation – Reclamation
- State Water Resources Control Board – State Water Board
- Division of Water Rights – Division
- Contra Costa Water District – CCWD

5. The water appropriated shall be limited to the quantity which can be beneficially used and shall not exceed **95,850** acre-feet per annum to be collected from **November 1** of each year to **June 30** of the succeeding year.

(0000005C)

The combined instantaneous maximum rate of diversion to offstream storage from Old River and Victoria Canal shall not exceed **200 cubic feet per second**.

(0000005J)

6. The maximum instantaneous combined rate of diversion for all diversions from Mallard Slough, Rock Slough, Old River and Victoria Canal under CCWD's Permit 20749 and License 10514 (Application 5941), and Reclamation Permits 12721, 11967, 12722, 12723, 12725, 12726, 11315, 11316, 16597, 11968, 11969, 11971, 11973, 12364, 16600, 15735 and 13776 shall not exceed: **540 cubic feet per second** for the months of June, July, August, September and October; **410 cubic feet per second** for the months of November, December, January, February and March; and **470 cubic feet per second** for April and May; the maximum rate of diversion from Victoria Canal shall not exceed **250 cubic feet per second**; and the maximum combined rate of diversion from Old River and Victoria Canal shall not exceed **320 cubic feet per second**.

(0000006)

7. Construction work shall be completed by December 31, 1999.

(0000008)

8. Complete application of the water to the authorized use shall be prosecuted with reasonable diligence and completed by December 31, 2025.

(0000009)

9. Permittee shall consult with the Division and, within one year from the date of this permit, shall submit to the State Water Board its Urban Water Management Plan as prepared and adopted in conformance with section 10610, et seq. of the California Water Code, supplemented by any additional information that may be required by the Board.

All cost-effective measures identified in the Urban Water Management Plan and any supplements thereto shall be implemented in accordance with the schedule for implementation found therein.

(0000029A)

10. Permittee shall install and maintain an outlet pipe of adequate capacity in the dam as near as practicable to the bottom of the natural stream channel, or provide other means satisfactory to the State Water Board, in order that water entering the reservoir which is not authorized for appropriation under this permit can be released. Evidence shall include photographs showing completed works or certification by a registered Civil or Agricultural Engineer.

(0050043B)

11. If the storage dam will be of such size as to be within the jurisdiction of the Department of Water Resources as to safety, construction under this permit shall not be commenced until DWR has approved the plans and specifications for the dam.

(0360048)

12. In accordance with the requirements of Water Code Section 1393, Permittee shall clear the site of the reservoir of all structures, trees, and other vegetation which would interfere with the use of the reservoir for water storage and recreational purposes.

(0120050)

13. The State Water Board reserves jurisdiction over this permit to change the season of diversion to conform to later findings of the State Water Board concerning availability of water and the protection of beneficial uses of water in the Sacramento-San Joaquin Delta and San Francisco Bay. Any action to change the authorized season of diversion will be taken only after notice to interested parties and opportunity for hearing.

(0000080)

14. This permit is subject to prior rights. Permittee is put on notice that, during some years, water will not be available for diversion during portions or all of the season authorized herein. The annual variations in demands and hydrologic conditions in the Sacramento - San Joaquin Delta are such that, in any year of water scarcity, the season of diversion authorized herein may be reduced or completely eliminated by order of the State Water Board, made after notice to interested parties and opportunity for hearing.

(0000090)

15. In order to prevent degradation of the quality of water during and after construction of the project, prior to commencement of construction, Permittee shall file a report pursuant to Water Code Section 13260 and shall comply with all waste discharge requirements imposed by the California Regional Water Quality Control Board, or by the State Water Board.

(0000100)

16. No water shall be diverted under this permit until Permittee has installed devices, satisfactory to the State Water Board, which are capable of measuring the flow: (1) directly diverted at Victoria Canal; (2) diverted into Los Vaqueros Reservoir from Old River and Victoria Canal; and (3) releases through or flowing out of the outlet facilities of Los Vaqueros Reservoir. Said measuring devices shall be properly maintained.

(0060046m)

17. Permittee shall maintain a daily record of direct diversion and collection to storage under this permit and submit such record to the Division on an annual basis, on or before March 1. The record of water use under this permit may not be combined with diversion or storage records for water use under other rights maintained by the Permittee.

(0090900)

18. The total quantity of water diverted and/or rediverted from Old River and Victoria Canal under this permit, together with that diverted under Reclamation Permits 12721, 11967, 12722, 12723, 12725, 12726, 11315, 11316, 16597, 11968, 11969, 11971, 11973, 12364, 13776, 16600, and 15735, issued pursuant to Applications 5626, 5628, 9363, 9364, 9366, 9367, 13370, 13371, 14858, 15374, 15375, 16767, 17374, 17376, 18115, 19304 and 22316 shall not exceed 180,675 acre-feet per annum from Old River and Victoria Canal combined, and also shall not exceed in any one-year period commencing on March 1, the sum of: (i) 177,000 acre-feet; (ii) 4,000 acre-feet to replace evaporation losses; and (iii) the difference between the quantity of water in storage in Los Vaqueros Reservoir at the end of the period and the quantity of water in storage in Los Vaqueros Reservoir at the beginning of the period from Old River and Victoria Canal combined. If the quantity of water in storage in Los Vaqueros Reservoir at the end of the period is less than the quantity of water in storage in Los Vaqueros Reservoir at the beginning of the period, the change in storage shall be subtracted from the 177,000 acre-feet.

Until further order of the State Water Board, the combined maximum annual diversion shall not exceed 222,000 acre-feet per annum from Old River, Rock Slough and Victoria Canal. Any such further order of the State Water Board shall be preceded by notice to all interested parties, by opportunity for hearing, and a showing that water can be diverted in excess of 222,000 acre-feet per annum, taking into account the needs of public trust uses, senior water right holders, and other beneficial uses. Any petition seeking such a further order of the State Water Board shall be accompanied by any environmental documentation required under California law. This requirement for a further order of the State Water Board shall not preclude Permittee from filing an appropriate petition or petitions for temporary changes or application(s) for temporary permits under laws existing at the time of the filing of the petition or application.

Provided, however, that if during the 12 months after the date when water is first diverted to storage in Los Vaqueros Reservoir there is adequate water available under the water rights listed above, the combined maximum diversion during that initial 12 months shall be 252,000 acre-feet from Old River and Rock Slough.

The total quantity of water under the permits on the above water rights distributed within the authorized place of use for use by Permittee's customers, in any one year period commencing March 1 shall not exceed 177,000 acre-feet.

(0000114m)

19. Permittee shall comply with all legally binding requirements of DFG, USFWS, and NMFS imposed under either the federal Endangered Species Act (16 U.S.C.A. Sections 1531 to 1544) or the California Endangered Species Act (Fish and Game Code Sections 2050 to 2098), with respect to the Los Vaqueros Project.

(0600500)

20. Permittee shall comply with the "Programmatic Agreement Among the U.S. Bureau of Reclamation, Contra Costa Water District, the California State Historic Preservation Office and the Advisory Council on Historic Preservation Regarding the Implementation of the Los Vaqueros Project", executed on February 3, 1993, and shall comply with it as it may be amended in the future. Permittee also shall comply with all historic property treatment plans prepared under the Programmatic Agreement.

Permittee shall continue to consult with Reclamation, U.S. Army Corps of Engineers, the Deputy Director for Water Rights, the State Historic Preservation Officer and the Advisory Council on Historic Preservation regarding cultural resources until all stipulations of the Programmatic Agreement have been completed to the satisfaction of the agencies. Permittee also shall comply with the "Procedure for the Protection of Historic and Cultural Properties" (36 CFR 60) and the implementing regulations of the Advisory Council on Historic Preservation, 36 CFR 800.

Permittee shall comply with the Memorandum of Understanding executed July 21, 1993 between CCWD and seven of the Native Americans Most Likely Descendants regarding treatment of Native American human remains and the selection of Native American monitors.

(0430300)

21. Permittee shall comply with mitigation measures 7-1 through 7-19 and 8-1 through 8-12 set forth at pages 19-5 through 19-8 of the final Environmental Impact Report/Environmental Impact Statement (EIR/EIS) dated September 27, 1993. Permittee also shall comply with mitigation measures 1 through 13 under "Additional Environment Commitments Related to the Fish and Wildlife Coordination Act Report" set forth at pages 19-13 through 19-14 of the Final EIR/EIS. The Deputy Director for Water Rights may grant a variance from any of these mitigation measures after making a finding that the variance will have no significant adverse effect on the environment. Any request for a variance shall include the reasons for the variance, environmental information necessary to demonstrate that it will not adversely affect the environment, and proof that Permittee has notified all interested parties of the request.

(0400500)

22. Permittee shall in cooperation with Reclamation implement the mitigation monitoring and reporting measures for Bay-Delta fishery resources, Bay-Delta water quality, vegetation resources, wildlife resources, cultural resources, and to comply with the Fish and Wildlife Coordination Act (16 U.S.C. Section 661 et seq.), which are set forth in the Environmental Commitments and Mitigation Monitoring Reporting Plan for the Los Vaqueros Project Stage 2 Environmental Impact Report/Environmental Impact Statement, dated October 27, 1993. Permittee in cooperation with Reclamation shall provide a report to the Deputy Director for Water Rights by April 1 of each year detailing the results of the previous year's monitoring, plans for the current year's monitoring, and the status of implementation of each mitigation measure required by this decision.

(0400500)

23. No diversion is authorized that would adversely affect the operation of the Central Valley Project or State Water Project under permits and licenses for the Projects in effect on the date of this Order. An adverse effect shall be deemed to result from Permittee's diversion at any time Reclamation and DWR have declared the Delta to be in balanced water conditions under the Coordinated Operation

Agreement or at any other time that such diversion would directly or indirectly require the Central Valley Project or the State Water Project to release water from storage or to reduce their diversion or redirection of water from the Delta to provide or assure flow in the Delta required to meet any applicable provision of state or federal law.

(0350900)

24. Permittee shall minimize increased levels of suspended sediments discharged to Old River during construction, maintenance and repair of the Old River Intake Facility and minimize loss of fish and riparian wildlife at the Old River intake facility construction site by: (1) installing floating silt curtains, silt fences, stormwater detention facilities, and other appropriate sediment control facilities; (2) mapping existing riparian/aquatic fish habitat prior to construction and taking steps to avoid losses to existing habitat during facility construction as much as possible; and (3) reestablishing suitable new habitat on newly constructed or existing levees to compensate for unavoidable losses. Further, Permittee shall perform all construction, maintenance and repair operations on the Old River intake facility only during the period from September 1 through December 30 of each year, unless USFWS and DFG authorized these activities during other periods. Best management practices shall be used to minimize direct and indirect impacts to fish and wildlife.

(0400500)

25. (a) Until the Rock Slough diversion is screened, water diversion from Rock Slough will be minimized under Permits 12725, 12726, and 15735 on Applications 9366, 9367, and 22316 of Reclamation from December 1 through June 30. Permittee shall maximize use of its screened intakes, unless monitoring at the intakes indicates, and DFG, USFWS and NMFS agree, that the incidental take of winter-run Chinook salmon, spring-run Chinook salmon, delta smelt and longfin smelt adults, juveniles, or larvae would be less at Rock Slough than another intake, or that these species are not present at Rock Slough. Permittee shall provide to the Division written concurrence, including the calendar dates when use is authorized, from DFG, USFWS and NMFS prior to use of any unscreened facilities.
- (b) During the period from March 15 through May 31 of each year, Permittee shall not divert water from the Old River or Victoria Canal points of diversion to offstream storage in Los Vaqueros Reservoir except when the reservoir storage level is less than 70,000 acre-feet in a below normal, above normal, or wet water-year, or less than 44,000 acre-feet in a dry or critical water-year ("emergency storage levels"). Water-year types will be as defined in the February edition of DWR Bulletin 120 or the Four Basin Index set forth in the permits and licenses of Reclamation. If reservoir storage is below emergency storage levels, Permittee may fill the reservoir only if:
- 1) Permittee has provided DFG with notification that reservoir storage is expected to be below emergency storage level and
 - 2) DFG concurs with the proposed diversion and rate of diversion.
- Permittee shall provide the Deputy Director for Water Rights a minimum 15-day notification after obtaining DFG concurrence with the proposed dates and rate of diversion in advance of any diversion. Unless within 15 days the Deputy Director for Water Rights objects to the proposed modification or proposes an alternative, the Permittee may divert at the identified rate of diversion.
- (c) Beginning in the February following the first operation of the Victoria Canal diversion, Permittee shall not divert water from any of its diversions to storage in Los Vaqueros Reservoir for 15 days from February 14 through February 28, provided that reservoir storage is at or above 90,000 acre-feet on February 1. If reservoir storage is at or above 80,000 acre-feet on February 1 but below 90,000 acre-feet, Permittee shall not divert water to storage in Los Vaqueros Reservoir for 10 days from February 19 through February 28. If reservoir storage is at or above 70,000 acre-feet on February 1, but below 80,000 acre-feet, Permittee shall not divert water to storage in Los Vaqueros Reservoir for five days from February 24 through February 28.
- (d) During the period April 1 to April 30, Permittee shall not divert from the Delta for use by CCWD unless Los Vaqueros Reservoir is below emergency storage levels as defined above, and will instead release up to 12,500 acre-feet of water from storage in Los Vaqueros Reservoir to meet

demand in the CCWD service area. In those instances where diversions are necessary due to the reservoir being at or below emergency storage levels, Permittee may divert from the Delta only for direct use by CCWD within the CCWD service area, and no water may be diverted to storage in Los Vaqueros Reservoir.

- (e) Permittee may submit to DFG, USFWS and NMFS by January 1 of each year, a proposal for modifying the dates of conditions (b), (c), and (d) to better protect threatened or endangered species. DFG may approve modification of the dates for the periods when the reservoir filling is to be avoided and the periods when no diversion shall occur if DFG determines the proposed modification of dates will be more effective in minimizing take of delta smelt and longfin smelt. If no response from DFG is received, Conditions (b), (c), and (d) shall apply. Condition (c) is a condition of DFG only. In addition, prior to modifying the dates of conditions (b) and (d), the concurrence of USFWS and NMFS is required. Permittee shall by February 15, or immediately if after February 15, notify the Deputy Director for Water Rights of the time period modifications for that year. Unless within 15 days the Deputy Director for Water Rights objects to the proposed modifications or proposes an alternative, Permittee shall implement the modifications.

(0400500)

26. If DFG, USFWS, or NMFS notifies CCWD that the periods described in permit terms 6 or 25(b) is desirable, then CCWD will, no later than January 15 of any year, provide the Division with a written request to modify the condition and any change approved by the Division shall be implemented.

(0400500)

27. Permittee shall construct, operate and maintain a fish screen and fish screen cleaning system at the Old River Intake Facility, satisfactory to DFG, USFWS and NMFS. The fish screen facility shall be constructed and made fully operational prior to operation of the Old River Intake Facility and by not later than January 1, 1997. In addition, the screen facility shall be designed and operated to achieve an average water approach velocity no greater than 0.2 feet per second for a 3/32" vertical slotted screen opening, and be operated to effectively screen fish greater than 21 millimeters long.

(0400500)

28. To avoid construction impacts to Swainson's hawks, surveys shall be conducted weekly beginning the first week of April through May 15 by a biologist acceptable to DFG to determine if any nesting is occurring within ½ mile of the Old River diversion point, and to determine whether there is any suitable nesting habitat within ½ mile. If nesting is occurring within ½ mile, construction may not be initiated or continued until August 15 without additional consultation with DFG. This term shall expire upon completion of construction.

(0400500)

29. Permittee shall, during construction of the Victoria Canal Intake Facility, implement measures to prevent a measurable increase in turbidity at the Victoria Canal Intake that could result in an exceedance of specified turbidity criteria contained in any permits, license, or court orders for Reclamation's Central Valley Project or DWR's State Water Project.

(0300800)

30. Permittee shall comply with the following:

- a) Diversions at Victoria Canal Intake under Permit 20749 of CCWD and Permits 12721, 11967, 12722, 12723, 12725, 12726, 11315, 11316, 11968, 11969, 11971, 11973, 12364, 13776, and 15735 of Reclamation can be made only when no adverse impact in water levels or water quality resulting from said diversions is detected at West Side Irrigation District (WSID) diversion points.

- b) The State Water Board reserves jurisdiction over the permits providing for diversions from the new intake at Victoria Canal for such additional time as necessary to determine if use of said point of diversion adversely impacts the water supply or water quality available to WSID. The State Water Board shall, after giving due notice thereof, make any further orders that it finds to be necessary concerning proper use of the point of diversion, and impose conditions providing for additional measurements or studies as it may deem necessary.
- c) Until further order of the State Water Board, CCWD shall make or cause to be made suitable field investigations, measurements, and studies, and shall install necessary measuring facilities, to determine the impact of diversions from the Victoria Canal Intake under permits granted or amended by this order on water levels and water quality in the vicinity of WSID diversion points and as otherwise required to fully comply with the provision of these permits. CCWD shall submit to the State Water Board, at such times as the Board may require, a report of such investigations, measurements, and studies and the results thereof. CCWD shall make its records of such investigations and measurements available for inspection by the State Water Board and shall allow authorized representatives of the State Water Board reasonable access to project works and properties for the purpose of gathering information and data.

(0300800)

31. The Victoria Canal Intake Facility screened diversion shall be constructed and shall be continuously functioning prior to and during any diversion operation on the Victoria Canal. Permittee shall construct, operate, and maintain fish screens and fish screen cleaning systems at the Old River and Victoria Canal facilities which conform with the fish screening system design criteria identified by DFG in its Incidental Take Permit. In addition, an average approach velocity of 0.2 feet per second shall be maintained at the screen in accordance with the reasonable and prudent measures in the USFWS delta smelt opinions for the Los Vaqueros Project (USFWS 1993a, as clarified and modified, Reclamation 1993) and the Victoria Canal Intake Facility (USFWS 2007).

(0400500)

32. The effectiveness of the no-fill and no-diversion timing and conditions to protect smelt in their various life stages shall be determined by an expanded monitoring program. Permittee shall continue to utilize the DFG approved Rock Slough Expanded Monitoring Program (circa 2003), Revised Biological Monitoring Program for the Old River Fish Screen Facility (circa 2000) and the Proposed Program to Sample the Overflow Structure at the CCWD Mallard Slough Pumping Plant (circa 2000). Permittee will monitor at Victoria Canal in a manner consistent with the methods approved by DFG for the Old River Fish Screen Facility. Additionally, to provide an indication of the possible presence of larval longfin and delta smelt, Permittee will perform additional plankton net sampling at Old River, Rock Slough and Victoria Canal. To provide an indication of the presence of the estuarine food-chain, Permittee will begin a program of zooplankton net sampling at Old River, Rock Slough and Victoria Canal. A summary of the real time monitoring for adults, juveniles, and larvae present near CCWD intakes and water quality data shall be transmitted at the beginning and middle of each month to DFG. The above-monitoring data will be used by Permittee to determine diversion of water at the Rock Slough, Old River, Victoria Canal, and Mallard Slough intakes. The monitoring information may be used to recommend changes to permit Conditions 26(b), 26(c), and 26(d) or as a trigger for other measures such as diversion reductions for the protection of the species identified by this permit. An annual summary of all collected information shall be submitted to DFG and the Division by October 31 of each year.

(0400500)

33. By August 1, 2010 and every three years subsequently, Permittee shall submit an updated study plan to DFG and the Division for approval to determine the presence of winter-run Chinook salmon, spring-run Chinook salmon, delta smelt and longfin smelt adults, juveniles, and larvae at all CCWD intakes. DFG and the Division shall provide written comments and requests regarding the adequacy of the submitted study plan and its elements by September 1 of each year in which an updated study plan is submitted. Permittee shall resubmit a revised study plan that addresses DFG's and the Division's comments and requests by October 1 of each year in which an updated study plan is

submitted. This study plan must be acceptable to and must be approved by DFG and the Division prior to November 1 of each year in which an updated study plan is submitted. If the Division does not respond in writing within 30 days, the study plan shall be considered approved by the Division. This continuous study shall begin by November 1 and shall continue until June 30 unless an alternative schedule is agreed to by DFG and the Division. A summary of the results of each study shall be transmitted to DFG and the Division in accordance with the schedule contained within the approved study plan. Fish sampling techniques and handling procedures shall be done so that fish mortality is minimized. Permittee shall coordinate with the ongoing Interagency Ecological Studies Program (IEP), and make its monitoring data available upon request by the IEP.

34. In-channel maintenance and repair operations on the Old River and Victoria Canal intakes shall take place from September 1 through November 15, except as approved by DFG and the Division. If emergency in-channel maintenance and repairs of the Old River or Victoria Canal intakes are required, DFG and the Division shall be notified within 48 hours.
35. Permittee shall relocate one agricultural diversion from the channel to behind the Victoria Canal fish screen, thereby screening the one 16-inch agricultural diversion and reducing overall entrainment potential at the agricultural siphon to help mitigate for the entrainment of delta smelt and longfin smelt. This will reduce overall entrainment potential at the agricultural siphon.
(0390500)
36. Delta smelt and longfin smelt habitat impacted by diversion operations during the term of this permit shall be mitigated by the acquisition and enhancement of 36 acres of shallow water tidal habitat approved by DFG that shall be maintained in perpetuity. The habitat shall be acquired or financial assurances provided to DFG prior to operation of the Victoria Canal Intake.
(0400500)
37. If DFG, pursuant to Fish and Game Code section 2081, amends the Incidental Take Permit or issues a new Incidental Take Permit with modified terms, Permittee shall petition the Division to amend the permit, as needed to conform to the new Incidental Take Permit.
(0400500)
38. To compensate for the loss of 0.7 acres of shallow water habitat, CCWD shall acquire, conserve, fund, and manage at least 2.1 acres of shallow water habitat at a mitigation bank or other location approved by USFWS, DFG, and NMFS. If 2.1 acres cannot be acquired prior to project impacts, CCWD shall provide DFG the following prior to construction: (1) an irrevocable letter of credit or other form of security approved by USFWS, DFG, and NMFS in the amount of \$73,500 to cover the costs of land acquisition, land conservation, and land management planning and (2) payment in the amount of \$10,500 for use as principal for a permanent capital endowment.
(0400500)
39. To prevent temporary degradation of surface water quality as a result of contaminant releases and runoff during construction, construction activities must comply with the Stormwater Pollution Prevention Plan prepared in July, 2008.
(0300800)
40. To mitigate for the loss of 0.8 acres of seasonal wetland, CCWD shall construct 1.6 acres of seasonal wetland at the Holland Tract Preserve.
(0400500)
41. Nothing in this permit shall alter the relative priority of diversions under Permit 20749 of CCWD and Permits 12721, 11967, 12722, 12723, 12725, 12726, 11315, 11316, 16597, 11968, 11969, 11971, 11973, 12364, 16600, 15735 and 13776 of Reclamation from that contained in State Water Board Decision 1629.
(0900999)

ALL PERMITS ISSUED BY THE STATE WATER BOARD ARE SUBJECT TO THE FOLLOWING TERMS AND CONDITIONS:

- A. The amount authorized for appropriation may be reduced in the license if investigation warrants.
(0000006)
- B. Progress reports shall be submitted promptly by Permittee when requested by the State Water Board until a license is issued.
(0000010)
- C. Permittee shall allow representatives of the State Water Board and other parties, as may be authorized from time to time by said State Water Board, reasonable access to project works to determine compliance with the terms of this permit.
(0000011)
- D. Pursuant to California Water Code sections 100 and 275, and the common law public trust doctrine, all rights and privileges under this permit and under any license issued pursuant thereto, including method of diversion, method of use, and quantity of water diverted, are subject to the continuing authority of State Water Board in accordance with law and in the interest of the public welfare to protect public trust uses and to prevent waste, unreasonable use, unreasonable method of use, or unreasonable method of diversion of said water.

The continuing authority of the State Water Board may be exercised by imposing specific requirements over and above those contained in this permit with a view to eliminating waste of water and to meeting the reasonable water requirements of Permittee without unreasonable draft on the source. Permittee may be required to implement a water conservation plan, features of which may include but not necessarily be limited to: (1) reusing or reclaiming the water allocated; (2) using water reclaimed by another entity instead of all or part of the water allocated; (3) restricting diversions so as to eliminate agricultural tailwater or to reduce return flow; (4) suppressing evaporation losses from water surfaces; (5) controlling phreatophytic growth; and (6) installing, maintaining, and operating efficient water measuring devices to assure compliance with the quantity limitations of this permit and to determine accurately water use as against reasonable water requirements for the authorized project. No action will be taken pursuant to this paragraph unless the State Water Board determines, after notice to affected parties and opportunity for hearing, that such specific requirements are physically and financially feasible and are appropriate to the particular situation.

The continuing authority of the State Water Board also may be exercised by imposing further limitations on the diversion and use of water by the Permittee in order to protect public trust uses. No action will be taken pursuant to this paragraph unless the State Water Board determines, after notice to affected parties and opportunity for hearing, that such action is consistent with California Constitution Article X, Section 2; is consistent with the public interest; and is necessary to preserve or restore the uses protected by the public trust.

(0000012)

- E. The quantity of water diverted under this permit and under any license issued pursuant thereto is subject to modification by the State Water Board if, after notice to the Permittee and an opportunity for hearing, the State Water Board finds that such modification is necessary to meet water quality objectives in water quality control plans which have been or hereafter may be established or modified pursuant to Division 7 of the Water Code. No action will be taken pursuant to this paragraph unless the State Water Board finds that: (1) adequate waste discharge requirements have been prescribed and are in effect with respect to all waste discharges which have any substantial effect upon water quality in the area involved, and (2) the water quality objectives cannot be achieved solely through the control of waste discharges.

(0000013)

- F. This permit does not authorize any act that results in the taking of a threatened or endangered species or any act that is now prohibited, or becomes prohibited in the future, under either the California Endangered Species Act (Fish & G. Code, §§ 2050 - 2097) or the federal Endangered Species Act (16 U.S.C.A. §§ 1531 - 1544). If a "take" will result from any act authorized under this water right, the Permittee shall obtain authorization for an incidental take prior to construction or operation of the project. Permittee shall be responsible for meeting all requirements of the applicable Endangered Species Act for the project authorized under this permit. (0000014)
- G. Permittee shall maintain records of the amount of water diverted and used to enable the State Water Board to determine the amount of water that has been applied to beneficial use pursuant to Water Code Section 1605. (0000015)
- H. No work shall commence and no water shall be diverted, stored or used under this permit until a copy of a stream or lake alteration agreement between DFG and the Permittee is filed with the Division. Compliance with the terms and conditions of the agreement is the responsibility of the Permittee. If a stream or lake agreement is not necessary for this permitted project, the Permittee shall provide the Division a copy of a waiver signed by DFG. (0000063)

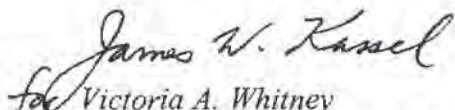
This permit is issued and permittee takes it subject to the following provisions of the Water Code:

Section 1390. A permit shall be effective for such time as the water actually appropriated under it is used for a useful and beneficial purpose in conformity with this division (of the Water Code), but no longer.

Section 1391. Every permit shall include the enumeration of conditions therein which in substance shall include all of the provisions of this article and the statement that any appropriator of water to whom a permit is issued takes it subject to the conditions therein expressed.

Section 1392. Every Permittee, if he accepts a permit, does so under the conditions precedent that no value whatsoever in excess of the actual amount paid to the State therefor shall at any time be assigned to or claimed for any permit granted or issued under the provisions of this division (of the Water Code), or for any rights granted or acquired under the provisions of this division (of the Water Code), in respect to the regulation by any competent public authority of the services or the price of the services to be rendered by any Permittee or by the holder of any rights granted or acquired under the provisions of this division (of the Water Code) or in respect to any valuation for purposes of sale to or purchase, whether through condemnation proceedings or otherwise, by the State or any city, city and county, municipal water district, irrigation district, lighting district, or any political subdivision of the State, of the rights and property of any Permittee, or the possessor of any rights granted, issued, or acquired under the provisions of this division (of the Water Code).

STATE WATER RESOURCES CONTROL BOARD


Victoria A. Whitney
Deputy Director for Water Rights

Dated: JUL - 8 2010

State Water Resources Control Board

JUL 05 2013

Mr. Russell Stein
California Department of Water Resources
3500 Industrial Blvd.
West Sacramento, CA 95691

Dear Mr. Stein

COMMENTS ON THE SECOND ADMINISTRATIVE DRAFT ENVIRONMENTAL IMPACT REPORT/ENVIRONMENTAL IMPACT STATEMENT FOR THE BAY DELTA CONSERVATION PLAN

Thank you for the opportunity to comment on the Second Administrative Draft Environmental Impact Report/Environmental Impact Statement (EIR/EIS) for the Bay Delta Conservation Plan (BDCP). The mission of the State Water Resources Control Board (State Water Board) and the Regional Water Quality Control Boards (Regional Water Boards) is to preserve, enhance, and restore the quality of California's water resources, and ensure their proper allocation and efficient use for the benefit of present and future generations. The State Water Board administers water rights in California, including water rights for the Department of Water Resources' State Water Project (SWP) and the U.S. Bureau of Reclamation's (USBR) Central Valley Project (CVP). The State and Regional Water Quality Control Boards also have primary authority over the protection of the State's water quality. The BDCP will require both water quality and water right approvals from the State Water Board, and possibly the Central Valley and San Francisco Bay Regional Water Quality Control Boards (collectively Water Boards). Accordingly, the Water Boards are responsible agencies for the BDCP pursuant to the California Environmental Quality Act (CEQA). As responsible agencies for the BDCP, the Water Boards conducted a preliminary review of parts of the BDCP and DEIR/EIS. The enclosure (BDCP EIR/EIS Review Document Comment Form) includes preliminary comments on these documents based on Water Board staff's limited review and current understanding of the project and environmental document. Staff has not reviewed all of the documents completely and also understands that additional changes are currently under development and consideration. Accordingly, once Water Board staff has additional time to review the BDCP and public draft EIR/EIS, we may amend these comments and provide additional detailed comments.

Water Board staff's review focused on:

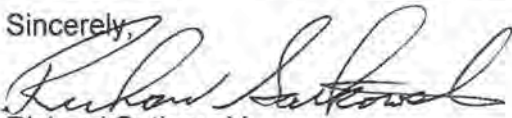
- The CEQA analysis associated with Alternatives 4 (the preferred project) and 8 (the alternative requested by the State Water Board to provide a broad range of operational alternatives), including the associated impact analysis and mitigation measures.

- Information needed for the Water Boards to facilitate the processing of: (a) water right actions associated with the project, including information needed for conducting a review of the likelihood of potential injury to any other legal user of water and the extent to which fish and wildlife would be affected by the change; (b) water quality certifications for the construction and operation of the conveyance facilities and restoration projects (focused on CM1); and (c) National Pollutant Discharge Elimination System (NPDES) permits that might be needed for regulating pollutant discharges to surface waters during construction and operation of the conveyance facilities and restoration projects.
- Information to inform changes to the Water Quality Control Plan for the San Francisco Bay-Sacramento/San Joaquin Estuary (Bay-Delta Plan) and its implementation. The State Water Board is in the process of developing and implementing updates to the Bay-Delta Plan and flow objectives for priority tributaries to the Delta to protect beneficial uses in the Bay-Delta watershed. Phase 1 of this work involves updating San Joaquin River flow and southern Delta water quality requirements included in the Bay-Delta Plan. Phase 2 involves other comprehensive changes to the Bay-Delta Plan to protect beneficial uses not addressed in Phase 1, focused on fish and wildlife beneficial uses. Phase 3 involves changes to water rights and other measures to implement changes to the Bay-Delta Plan from Phases 1 and 2. Phase 4 involves developing and implementing flow objectives for priority Delta tributaries outside of the Bay-Delta Plan updates. Information from the BDCP process will primarily inform potential changes to the Bay-Delta Plan related to Phase 2 and likely changes to water rights in Phase 3.

In addition to reviewing the BDCP documentation, Water Board staff reviewed the comments on the December 2012 Administrative Draft BDCP that were prepared by National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS), and the 2012 Red Flag comments on the February 2012 version of the BDCP Effects Analysis that were submitted by the U.S. Bureau of Reclamation (USBR) and the California Department of Fish and Wildlife (CDFW), USFWS, and NMFS (collectively the fishery agencies). State Water Board staff generally support the fishery agencies' comments contained in these documents and agree that the issues identified should be resolved.

Water Board staff look forward to continue working with the BDCP environmental review effort for this project. To facilitate our review and consideration of approvals needed for the BDCP, Water Board staff requests the opportunity to participate in on-going technical discussions concerning the BDCP and environmental review process. Water Board staff are also available to continue discussions regarding the process for considering the various approvals needed from the Water Boards for the project. If you have any questions concerning this matter, please contact me at rich.satkowski@waterboards.ca.gov or (916) 341-5439, or Karen Niiya at karen.niiya@waterboards.ca.gov or (916) 341-5365. Written correspondence should be addressed as follows: State Water Resources Control Board; Division of Water Rights; Attn: Richard Satkowski or Karen Niiya; P.O. Box 2000; Sacramento, CA 95812.

Sincerely,



Richard Satkowski,
Senior Water Resources Control Engineer
Division of Water Rights

Enclosure

Enclosure to July 5, 2013 Letter from Water Board's Staff

BDCP EIR/EIS Review Document Comment Form

Document: Administrative Draft—Chapter No: General Comments

Comment Source: SWRCB

Submittal Date: 7/5/2013

No.	Topic	Line #	Comment	ICF Response
1	Water Rights/ Bay-Delta Plan		As indicated in the EIR/EIS, the State and Regional Water Boards (Water Boards) have discretionary approval authority over the water right and water quality aspects of the proposed project and are responsible agencies for this project under the California Environmental Quality Act (CEQA). As responsible agencies under CEQA, the Water Boards must review and consider the environmental effects of the project identified in the EIR/EIS that are within their purview and reach their own conclusions on whether and how to approve the project involved. (Cal. Code Regs., tit. 14, § 15096, subd. (a).) In order for the Water Boards to determine whether the EIR/EIS adequately addresses all of the proposed actions, please identify all of the changes to water quality objectives, water rights, and other approvals that are needed for the BDCP. Specifically, please identify which water quality objectives are proposed to be changed, any new water rights that may be requested and any proposed changes to water rights. A table identifying the proposed changes in the beginning chapters of the EIR/EIS would be helpful. All of the proposed approvals that are needed by the BDCP must be identified and fully evaluated (including cumulative impacts) in the EIR/EIS and appropriate mitigation proposed in order for the Water Boards to consider those approvals. The Water Boards are available to work with the project proponents to develop the above information.	
2	Bay-Delta Plan		To consider changes to the Bay-Delta Plan needed for the BDCP, the State Water Board will need to independently review the scientific basis for any changes to the Bay-Delta Plan and make a determination that those changes are reasonably protective of beneficial uses. To support any changes needed for the BDCP, the scientific basis for those changes should be provided in the BDCP, EIR/EIS or other documentation (including changes to non-fish and wildlife flow objectives). The State Water Board will then independently evaluate this information and other relevant information to determine what, if any, changes to make to the Bay-Delta Plan to protect beneficial uses. The State Water Board will also need to conduct an anti-degradation analysis for any changes that may result in a degradation in water quality. Documentation and analysis to support that analysis should also be provided. Pursuant to state and federal law, the State Water Board is required to regularly review and update the Bay-Delta	

			Plan to assure that it is reasonably protective of beneficial uses. Future updates to the Bay-Delta Plan will continue to be based on best available science and may therefore modify any BDCP elements that are affected by the Bay-Delta Plan to assure the reasonable protection of beneficial uses.	
3	Water Rights		Before the State Water Board may approve a change in a water right permit or license needed to implement the BDCP, including a change to the point of diversion specified in the permit or license, the Board must find that the change will not injure any legal user of water. (Wat. Code, § 1702.) Information concerning the extent, if any, to which fish and wildlife would be affected by the change shall also be considered. (Wat. Code, § 1701.2) The State Water Board has an independent obligation to consider the effect of the BDCP on public trust resources and to protect those resources where feasible (<i>National Audubon Society v. Superior Court</i> (1983) 33 Cal.3d 419), and to prevent the waste, unreasonable use, unreasonable method of use, or unreasonable method of diversion of water (Cal. Const., art. X, § 2; Wat. Code, § 275). Pursuant to its authority under the Water Code, the State Water Board may request additional information outside of the CEQA process to meet the State Water Board's public trust and other obligations. Accordingly, while BDCP parties may determine that CEQA does not require an analysis of all of the issues pertaining to water right change petition approval (including impacts to other legal users of water and public trust resources), it would assist the State Water Board in its consideration of the BDCP if the EIR/EIS discussed these issues. Given the similarity of the scope of analyses, it would be efficient to address these issues in one document.	
4	Water Rights, Bay-Delta Plan		As indicated in several comment letters on the BDCP environmental review process, for the Water Boards to consider any water quality and water rights applications or petitions for the BDCP, environmental documentation prepared for the project must disclose the significant effects of the proposed project and identify a reasonable range of interim and long-term alternatives that would reduce or avoid the potential significant environmental effects. The BDCP does not appear to propose interim water project operational measures needed to protect fish and wildlife beneficial uses beyond those requirements associated with biological opinions. The measures required by the biological opinions are designed to avoid jeopardy of listed species which is not the same standard as the standard of reasonable protection of beneficial uses. Since the State Water Board is required by law to periodically review and update, as appropriate, the Bay-Delta Plan, it will continue its independent review and update of the Bay-Delta Plan, and will establish requirements during the interim that are based on the best available science at the time of the update. The Water Boards will also need to independently evaluate the long-term measures proposed by BDCP and reach an independent conclusion on whether to approve changes associated with the project.	

5	CWA 401	Section 401 of the Federal Clean Water Act (CWA) requires any applicant for a federal license or permit, which may result in any discharge to navigable waters, to obtain certification from the State that the discharge will comply with the applicable water quality parameters in the CWA. Under section 303 of the CWA and under the Porter-Cologne Water Quality Control Act, the State Water Board and U. S. Environmental Protection Agency approved, the Bay-Delta Plan. Additionally, the California Regional Water Quality Control Boards have adopted, and the State Water Board has approved, Water Quality Control Plans (basin plans) for each watershed basin in the State. These Basin Plans designate the beneficial uses of waters within each watershed basin, and water quality objectives designed to protect those uses pursuant to Section 303 of the Clean Water Act. (33 U.S.C. § 1313.) The beneficial uses together with the water quality objectives that are contained in the Basin Plans and state and federal anti-degradation requirements constitute California's water quality standards. If the Project does not comply with one or more of the water quality objectives or criteria, then DWR must identify the actions that it will take to bring its Project into compliance with the applicable water quality limits in order to fully protect and maintain the beneficial uses. When submitted, DWR's application for certification must meet the application filing requirements specified in Cal. Code Regs., tit. 23, section 3856. The State Water Board may request additional information to clarify, amplify, correct, or otherwise supplement the contents of the application. Supplemental information may include evidence of compliance with the water quality control plans. (Cal. Code Regs. tit. 23, § 3836.) A certification is issued when the State Water Board determines that an application for certification is complete and there is reasonable assurance the operation of the Project will comply with water quality standards and other appropriate requirements. The State Water Board must analyze potential Project-related environmental impacts to Project affected water bodies prior to making a determination that continued operation of the Project will be protective of the designated beneficial uses of the watershed.	
6	BDCP, EIR/EIS	As discussed in the State Water Board's letter to Gerald Meral of April 19, 2011 and other correspondence, in order for the State Water Board to consider changes to the Bay-Delta Plan and water rights, the BDCP must evaluate a sufficiently broad range of alternatives. Alternatives that reduce reliance on water from the Delta should be included in this range. Accordingly, it seems appropriate to include reduced reliance on water from the Delta as a conservation measure for the project and as mitigation for impacts associated with impacts related to inadequate water supplies to meet all needs for water within and outside of the Delta.	

7	BDCP		The decision tree for Delta outflow includes four operational scenarios. Compared to the no-project alternative (which appears to be the appropriate comparison point for long-term effects), it appears that all of these operational scenarios decrease total Delta outflow (see Attachment 1: State Water Board analysis) in the late-long term. The justification for this limited range of Delta outflow scenarios is not clear given that there is strong information on the possible need for more Delta outflow for the protection of aquatic resources and the uncertainty that other conservation measures will be effective in reducing the need for flow. Specifically, recent research indicates that restoration of tidal marsh may not be feasible, possible, or effective. Accordingly, it appears appropriate to include a broader range of Delta outflows under the decision tree process.	
8	BDCP		The Decision Tree process described in Table 3.4.1-1 of the BDCP indicates that structured hypothesis testing would be conducted through a collaborative science program (a) to determine whether or not additional spring outflow above D-1641 requirements is needed to achieve longfin smelt abundance objective; and (b) to determine whether or not the position of the fall low salinity zone needs to be in Suisun Bay and the lower Delta to achieve BDCP objectives for Delta smelt habitat and abundance. Although BDCP text on page 3.4-19, starting on line 22, indicates that, prior to commencement of dual conveyance operation, hypotheses supporting each criterion will be tested in detail, and data will be collected, it is unclear whether operational changes and adaptive management will be part of the testing. Interim and long-term provisions for these measures should be developed and included in the BDCP to better inform decision making regarding adaptive management for the protection of all of the covered species and those that may be listed in the future.	
9	BDCP		Although the Decision Tree process proposes hypothesis testing for delta smelt and longfin smelt, it does not appear to take into consideration the flows that might be needed for other aquatic species, such as sturgeon and salmonids. The decision tree process should include consideration of flow needs for other listed species, as appropriate.	
10	BDCP		Decision-making authority for the Decision Tree does not appear to be explained in either the BDCP or the EIR/EIS. The role of the fishery agencies, State Water Board and other groups should be specified in the BDCP and EIR/EIS. Any data, analysis, and conclusions developed as part of the decision tree process, including fishery agency review and recommendations should be included in regularly-scheduled reports as part of the Plan of Implementation.	
11	EIR/EIS		The environmental impacts associated with the range of potential adjustments to CM1 operations anticipated as part of adaptive management, and as part of potential real-time operations changes, do not appear to be included in the EIR/EIS. An	

			evaluation of the potential impacts should be included, especially potential impacts to species that were not the basis for the proposed operations.	
12	EIR/EIS		The EIR/EIS concludes that there are potentially significant impacts that are not mitigable. The EIR/EIS should describe how the BDCP is still consistent with the two coequal goals, especially the goal of protecting, restoring, and enhancing the Delta ecosystem. The BDCP proponents will also need to develop a statement of overriding considerations that explains how the benefits of the project outweigh the unavoidable adverse environmental effects.	
13	EIR/EIS		The EIR/EIS should provide tabular quantitative comparisons of the various alternatives, including flows, exports, temperatures, and other quantitative information. An example of such a table, prepared by State Water Board staff, is included as Attachment 2)	
14	BDCP/ EIS/EIR		The BDCP relies on habitat restoration to provide adequate ecosystem conditions to achieve the biological goals and objectives of the project. Available tidal energy, and the associated tidal exchange, might be attenuated as restoration projects begin to be constructed and put into operation. The reduction in tidal exchange might reduce the export of phytoplankton and reduce turbidity. Both of these effects might reduce the effectiveness of existing and future restoration areas. The BDCP and the EIR/EIS do not appear to analyze the effects of changes in tidal energy exchange that may result after construction and implementation of habitat restoration projects, and how those changes in tidal energy might affect transport of food and turbidity from the restored areas to locations where pelagic species are present. The Independent Science Board, in its Habitat Restoration Review (2013) suggested modeling research to evaluate how dissipations in tidal energy may reduce tidal ranges such that the effectiveness of restoration sites is reduced. Water Board staff support this approach.	
15	BDCP		Section 3.6.4.2 of the BDCP describes North Delta Diversion Bypass Flow Criteria. The proposed bypass flow criteria consist of constant low-level pumping, initial pulse protection, and three levels of post-pulse operations. Page 3-156, line 32 describes Post-Pulse Water Operations, which describes how Level I, Level II, and Level III bypass flows would be initiated. However, the process by which operations should return to Levels II and I pumping for the protection of fish species was not described, but should be.	
16	BDCP		Section 3.4.1.4 of the BDCP describes how operation of the conveyance facility will be controlled through criteria that are partly prescribed and partly adjustable through three processes: decision trees, adaptive management, and real-time operations. Although text starting at line 3 on Page 3.4-3 indicates that adaptive management would be used to modify operations after initiation of north Delta diversion operations, text on pages 3.4-19 through 3.4-20 does not specify that adaptive management will be implemented for either Spring Outflow or Fall Outflow	

		after initiation of north Delta diversion operations. Given the uncertainty regarding the quantity of Spring and Fall outflow needed to achieve biological objectives and the likelihood that this uncertainty will not be fully resolved by the time the conveyance facility is in operation, it seems appropriate to include these operational parameters in the adaptive management program. Text on Page 3.4-21, starting at line 15, identifies the operational parameters that would be subject to real-time operation adjustments within limits described in Section 3.4.1.4.3: Delta Cross Channel Gates, Head of Old River Gate, South Delta Diversions, and North Delta Diversions. It is not clear from the discussion whether these operational parameters would also be subject to adaptive management. These operational parameters should also be included in the adaptive management program. The North Delta Diversion's operational parameter is associated with north Delta bypass flows. The north Delta bypass flows should therefore be included in the text on Page 3.4-21, starting at line 15, for clarity. This will provide consistency with text on Page 3.4-23, starting at line 1, which states that north Delta Diversion bypass flows will be part of real-time operations. It is not clear how the real-time operational ranges described in Section 3.4.1.4.3 were considered in the environmental analysis contained in the EIR/EIS. Please explain. Text on Page 3.4-21 states that some operational parameters would not be subject to real-time adjustments, as they would be operated according to criteria described in Section 3.4.1.4.3. For clarity, the specific operational parameters that will not be subject to real-time adjustments should be listed here. It appears that the operational parameters that will not be subject to real-time adjustments are: Old and Middle River/San Joaquin inflow/export ratio, spring outflow, fall outflow, winter and summer outflow, and export to inflow ratio. To address uncertainty in the various measures these operational parameters should be included in the adaptive management program. Page 3.4-23, line 1: The text suggests real-time operations of the North Delta Diversion bypass flows between December and June would not operate according to the criteria described in Table 3.4.1-2. Specifically, the text would allow real-time operations to operate at lower bypass flows than those described in Table 3.4.1-2, and it would not allow three-level post-pulse operation. This discussion is confusing, and should be clarified. Page 3.4-23, line 10: The text should include real-time operations as another way of informing the implementation of CM1.	
--	--	---	--

17	BDCP	The BDCP, page 9-6, line 35 states the Combined Scenario 5 (CS5) alternative was developed to be an operational scenario focused on maximizing ecological benefits for aquatic covered species in the Delta, assuming that only flow changes would provide benefits, without consideration of the likely benefits provided by the BDCP's other conservation measures. The CS5 alternative became an "alternative to take" instead of a project alternative because the BDCP indicates this alternative would require water management operations outside of the BDCP Area, and that it would conflict with existing legal constraints, causing unresolvable conflicts between species needs and affecting upstream water rights. (Section 9.1.3.2.3 of the BDCP) The underlying science that was used to develop the CS5 alternative, and the modeling analysis that was performed to evaluate the alternative do not appear to be included in the BDCP and EIR/EIS documentation. This information should be made available.	
----	------	--	--

BDCP EIR/EIS Review Document Comment Form

Document: Administrative Draft—Executive Summary and Chapter No. 1__ Introduction

Comment Source: SWRCB

Submittal Date: 7/5/2013

No.	Page	Line #	Comment	ICF Response
1	ES-34	34	This paragraph indicates a summary of existing CVP and SWP operations would be briefly summarized immediately following, but no summary was provided. Please provide the summary along with a summary of the proposed operations under the alternatives.	
2	ES-36	25	The section describing Scenario H does not refer the reader to a technical appendix where the underlying science can be found. An appendix with this information should be provided and referenced where appropriate in the document.	
3	ES-36	25	The section describing Scenario H refers to biological objectives, but does not tell the reader where the biological objectives can be found.	
4	ES-40	43	The Executive Summary indicates the project proponents anticipate approval from State Water Board for new SWP points of diversion in the Delta, which would likely be subject to conditions on DWR's and USBR's water rights to protect beneficial uses in the Delta. It further states that such changes "would not include changes in water rights; however, there are concerns that the BDCP could result in the potential for increased exports of water." This statement is incorrect. Implementation of the BDCP project will require changes to water rights and water right requirements. Further, the proposed project may affect other legal users of water through changes in salinity and flows. These issues are further discussed elsewhere in this comment letter.	
5	1-18 – 1- 23		Section 1.6.1 describes the use of this EIR/EIS by other entities, and provides a table summarizing the agencies that might use this document, including their specific review, approval, or other responsibilities. Based on initial review of the second administrative draft EIR/EIS, the Water Boards will need additional information beyond what is provided in the document to implement their permitting authority. As currently written, section 1.6.1 does not state whether the project proponents intend to provide supplemental information at a later date to the individual approving agencies to augment the information in the EIR/EIS.	

6	1-24	18-22	Similar to the executive summary, the EIR/EIS states that the project proponents anticipate approval from the State Water Board for new points of diversion in the Delta for the proposed project. The EIR/EIS further states that such changes would not include changes in water rights, but there are concerns that the BDCP could result in the potential for increased exports of water. These statements are unclear and contradictory and should be clarified. The proposed project would result in changes to water rights and could potentially affect other legal uses of water. As explained above, these issues should be fully described and analyzed in the EIR/EIS.	
---	------	-------	--	--

BDCP EIR/EIS Review Document Comment Form

Document: Administrative Draft—Chapter No. 2 *Project Objectives and Purpose and Need*

Comment Source: SWRCB

Submittal Date: 7/5/2013

No.	Page	Line #	Comment	ICF Response
			Possible Comments to be provided on public draft	

BDCP EIR/EIS Review Document Comment Form

Document: Administrative Draft—Chapter No. 3 Description of Alternatives

Comment Source: SWRCB

Submittal Date: 7/5/2013

No.	Page	Line #	Comment	ICF Response
1	General		Chapter 3 should include a table defining the specific operational assumptions under the various scenarios.	
2	3-155		The description of the objectives for the North Delta Diversion Bypass Flows contained on this page is different than the objectives description contained in Appendix 5A, page B-95. EIR/EIS Chapter 3, page 3-155 states: “The objectives of the north Delta diversion bypass flow criteria include regulation of flows to: (1) maintain fish screen sweeping velocities; (2) reduce upstream transport from downstream channels; (3) support salmonid and pelagic fish transport to regions of suitable habitat; (4) reduce predation effects downstream; and (5) maintain or improve rearing habitat in the north Delta.” EIR/EIS Appendix 5A, page B-95 states: “Objectives include flows or the functional equivalent thereof to (1) provide North Delta bypass criteria with adaptive limits, (2) provide for Fall X2, (3) support salmonid and pelagic fish transport to regions of suitable habitat, (4) reduce predation effects downstream, and (5) maintain or improve rearing habitat in the north Delta.” Please clarify.	
3	3A-7	All	Chapter 3A-7 was developed in May 2011, and it is not clear whether changes to operations have been made to the modeling since then. Please clarify whether Chapter 3A-7 has been modified to reflect the information contained in the fishery agencies’ “Red Flag Letters”?	

BDCP EIR/EIS Review Document Comment Form

Document: *Administrative Draft—Chapter No. 4__ Approach to the Environmental Analysis*

Comment Source: SWRCB

Submittal Date: 7/5/2013

No.	Page	Line #	Comment	ICF Response
1	4-3	32	The descriptions of the CEQA and NEPA baselines are unclear. A table would be helpful to summarize this information.	
2	4-5	7	The No Action Alternative is described, and its use in the NEPA analysis is described, but a corresponding description for the CEQA analysis is missing. Please provide.	
3	4-7	16	The first paragraph of this section appears to contain an error in its description of CEQA and NEPA regulations for assessing cumulative effects. For appropriate revisions, please refer to the Public Resources Code and CEQA Guidelines sections already cited in the paragraph.	

BDCP EIR/EIS Review Document Comment Form

Document: Administrative Draft—Chapter No. 5 *Water Supply (including water rights)*

Comment Source: SWRCB

Submittal Date: 7/5/2013

No.	Page	Line #	Comment	ICF Response
1	5-38	15-18	CM1, the proposed project, includes three water diversions at Intakes 2, 4 and 5 on the Sacramento River near Hood in the north Delta. DWR's water right permits include only one point of diversion (near Intake 4). DWR may be required to file change petitions to add points of diversion and points of rediversion to its permits.	
	5-34	7-38	The EIR/EIS does not include a section on DWR's and USBR's existing water rights, proposed changes to those water rights, and any new rights that DWR or USBR may seek to acquire. Such a write-up should be included within the water supply chapter or as an attachment to the document. The description of existing water rights, proposed changes to existing water rights, and any new rights needs to be specific and include (1) the water right and/or claim of water right, (2) the existing and proposed point(s) of diversion, point(s) of rediversion, place(s) of use, beneficial use(s) of water, and schedule to complete beneficial use of water, and (3) whether a petition for change or extension of time has been filed in connection with the water right and its status. To assist in describing the water rights and claim of water rights, the EIR/EIS should include maps that show the above items.	
	5-35	All		
	5-36	All		
	5-37	1-32		
2	5-34	7-38	Implementation of CM2 may require water right change petitions on existing permits to add a point of rediversion on the Sacramento River at the Fremont Weir and to change the place of use by adding the Yolo Bypass. This should be coordinated with the State Water Board and addressed in the EIR/EIS or associated documents as discussed above.	
	5-35	All		
	5-36	All		
	5-37	1-32		
3	5-34	7-38	According to the Division of Water Rights' records, DWR and USBR have 10 and 32 pending time extension petitions, respectively, for water rights within the Bay-Delta watershed or export areas. All of these petitions have been noticed and protested. It appears that only some of DWR's and USBR's time extension petitions are directly related to the BDCP. Please identify the existing time extension petitions that are directly related to the BDCP as well as their status. In addition, it appears that the existing time extension petitions that are directly related to the BDCP may need to be amended to allow more time for construction and operation of CM1. Normally, the baseline for determining significant effects of a petition for a time extension is the current environmental setting. (Cal. Code Regs., tit. 14, § 15125.) When the baseline is the current environmental setting, it includes the existing facility or ongoing project and whatever impacts it currently has on the environment. Because a time extension may allow construction of new or expanded facilities or application of water to beneficial use beyond what is currently occurring, an extension has the potential to have a significant effect on the environment that must undergo appropriate CEQA review.	
	5-35	All		
	5-36	All		
	5-37	1-32		

			The Board will evaluate the environmental impacts associated with approving the time extensions. Specifically, it will evaluate the difference between the amount of water already put to beneficial use and the total amount authorized to be used. An exemption from CEQA may apply in certain situations, but the State Water Board cannot evaluate whether one would apply to DWR's or USBR's permits without more information.	
4	5-34 5-35 5-36 5-37	7-38 All All 1-32	In order to approve petitions to extend the deadlines to complete construction and apply water to beneficial uses specified in water right permits, the State Water Board must make findings regarding diligence pursuant to California Code of Regulations, title 23, section 844, including a finding that due diligence has been exercised, that failure to comply with previous time requirements has been occasioned by obstacles which could not reasonably be avoided, and that satisfactory progress will be made if an extension of time is granted. While not required by CEQA, this information should be provided with any petitions.	
5	5-34 5-35 5-36 5-37	7-38 All All 1-32	While not required pursuant to CEQA, an injury analysis pursuant to Wat. Code, § 1702 is needed before the State Water Board can authorize changes to DWR's or USBR's water rights. It should include information to indicate that a change will not operate to the injury of any legal user of the water involved. Among the water users that may claim injury to their water supply or quality are (1) junior water right holders, including Water Right Term 91 permittees and licensees, (2) western, interior, and southern Delta agricultural users, and (3) western Delta municipal users. Information showing that injury will not occur to these and other legal users of water should be provided with any change petitions.	
6	8-421 App. 5A	All B-40	The EIR/EIS shows the projected increase in Suisun Marsh salinity under the proposed project. Please explain how such changes will reasonably protect fish and wildlife beneficial uses and not injure other legal users of water.	
7	App. 5A App. 5A	B-95 B-104	It is unclear what averaging period is proposed for the bypass flows on the Sacramento River. Without knowing what averaging period will be used, it is not possible to assess the proposed bypass flows. Will diversions be based on the monthly average flow, daily average flow, instantaneous flow, or some other metric? Please explain.	
8	App 5A	B-104 and C-738	Flows at Freeport reverse occasionally at ebb tide under current conditions. If proposed tunnel diversions are based on an average flow rather than instantaneous flow, reverse flows at Freeport would become more common and more extreme in the period from July to November. Additionally, flows at Freeport upstream of the intakes are projected to decrease during that time period, as compared to existing conditions. Please specify what metric (average or instantaneous) will be used in implementation and include an analysis of how the proposed diversions will affect the instantaneous flows at Freeport and, consequently, biological resources, rather than just the monthly average flows.	
9	App. 5A	B-99	The proposed OMR values listed are monthly average flows "for use in modeling," but it is unclear what averaging period would be used for actual operations. This is an important consideration that may affect the protection afforded by this action, so it should be explicitly addressed.	
10	App 5A	B-6 Table B-18	It appears from Table B-18 that all alternatives assume VAMP flow requirements at Vernalis. In the text starting on Pg B-6 this is unclear. Please clarify whether or not VAMP is included in each alternative.	

BDCP EIR/EIS Review Document Comment Form

Document: Administrative Draft—Chapter No. 6 Surface Water (including water transfers)

Comment Source: SWRCB

Submittal Date: 7/5/2013

No.	Page	Line #	Comment	ICF Response
1	6-8	27-31	The EIR/EIS states: "Suisun Marsh is located west of the Delta. Water Right Decision 1485 (D-1485) issued by the [State Water Board] in 1978 established channel water salinity standards and a water quality monitoring program and provided for the recently adopted Suisun Marsh Habitat Management, Preservation, and Restoration Plan (Bureau of Reclamation et al. 2010)." The EIR/EIS should add that the Suisun Marsh criteria are also contained in Revised Water Right Decision 1641 issued in 2000. The EIR/EIS should also clarify that the State Water Board has not taken any action to approve the Suisun Marsh Habitat Management, Preservation, and Restoration Plan to determine whether that plan as implemented provides for the reasonable protection of fish and wildlife beneficial uses.	
2	6-38	8-10 and 22-27	The EIR/EIS states that the State Water Project (SWP)/Central Valley Project (CVP) operations are managed to meet instream flow requirements, water right agreements, and refuge water supply agreements in the Sacramento and San Joaquin valleys. Furthermore, the EIR/EIS discusses alteration of SWP/CVP operations. The document identifies the project proponents to be DWR and the following six water contractors: Alameda County Flood Control and Water Conservation District, (Zone 7), Kern County Water Agency, Metropolitan Water District of Southern California, San Luis and Delta Mendota Water Authority, Santa Clara Valley Water District, and Westlands Water District. The document further states that additional water contractors may become project proponents in the future. If additional water contractors become water proponents, will the EIR/EIS be revised accordingly? Is the USBR considered a project proponent?	
3	6-63	9-13	The EIR/EIS refers to reservoir storage and water transfers. If the proposed project is implemented, DWR may be able to increase the frequency and amount of water transferred using the export pumps. The document should include a quantitative analysis of the maximum amount of water that can be transferred (exported) due to	

		construction and operation of proposed project. This includes water transfers of project water or other private party transfers. In addition, the document should include information on whether additional water transfers through the CM1's proposed north delta intakes would impact individual water right holders located between the proposed north and existing south Delta water intakes. Most water transfers are temporary, one-year transfers pursuant to Water Code section 1725. If DWR believes that water may be transferred under its rights in consecutive years due to the BDCP, DWR should file a petition for a long-term transfer pursuant to Water Code section 1735.	
--	--	---	--

BDCP EIR/EIS Review Document Comment Form

Document: Administrative Draft—Chapter No. 7__Groundwater

Comment Source: SWRCB

Submittal Date: 7/5/2013

No.	Page	Line #	Comment	ICF Response
1	7-46, 7-47, 7-48	15-42 All, 1-8	Discharge of dewatered groundwater to surface water poses a threat to surface water quality and is regulated by the Water Boards. The construction of CM1 will require groundwater dewatering operations for the construction of intakes, intake pipelines, and conveyance facilities (tunnels). The groundwater pumping would occur 24 hours per day, 7 days a week. Dewatering requirements were assumed to range from approximately 240 to 10,500 gpm. Groundwater would be treated, as necessary, and discharged to surface waters in accordance with a National Pollutant Discharge Elimination System (NPDES) permit. The EIR/EIS describes the types of construction requiring dewatering and the range of dewatering pumping rates. However, the number of discharge locations and duration of discharges are not discussed. Dewatering discharges are typically considered a low or limited threat to water quality. However, the EIR/EIS should consider the possibility of encountering groundwater that has been polluted by leaking underground fuel storage tanks and spills of pesticides or other toxic or hazardous substances. It may be necessary to treat the water prior to surface water discharge to prevent impacts to water quality. The Water Boards would regulate these surface water discharges under an NPDES permit. The project proponent should plan to submit a Report of Waste Discharge at least one year prior to beginning construction. Based on the proposed discharge rates, the Water Boards may authorize discharge under an individual NPDES permit or Order R5-2008-0082-01, <i>General Order for Limited Threat Discharges of Treated/Untreated Groundwater from Cleanup Sites, Wastewater from Superchlorination Projects, and Other Limited Threat Wastewaters to Surface Water</i> (Limited Threat General Order).	

			Application requirements for the Limited Threat General Order are contained in Attachment G of Order R5-2008-0082-01, and can be found on the Central Valley Water Board website at http://www.waterboards.ca.gov/centralvalley/board_decisions/adopted_orders/general_orders/r5-2008-0082-01.pdf. In general, the applicant must include USEPA Application Forms 1 and 2D; State Water Board Form 200, including a project map which shows the location of the project, discharge point(s), and receiving water; a full description of the proposed project on official letterhead; blueprints of the proposed treatment system signed by a Registered Engineer or Geologist (if applicable); analysis of the proposed effluent for pollutants listed in Attachment B, Attachment C (if applicable), and any applicable 303(d) listed pollutants for the receiving water if proposing to discharge to an impaired waterbody; an evaluation of reclamation options; public notice requirements; and the appropriate fee. Water quality sampling for all constituents listed in Attachment B and C of the Limited Threat General Order and a sample of the 5-day biochemical oxygen demand (BOD₅).	
--	--	--	---	--

BDCP EIR/EIS Review Document Comment Form

Document: Administrative Draft—Chapter No. 8__Water Quality

Comment Source: SWRCB

Submittal Date: 7/5/2013

No.	Page	Line #	Comment	ICF Response
1	8-9	23	Potential project related impacts on water quality due to selenium should be further evaluated. The project will result in significant increases of the San Joaquin River flow and subsequent selenium loading into the Delta and Suisun Bay that is listed as impaired by selenium. Yet, the forecasted selenium concentrations for various alternatives (e.g. Table M-10A) indicate no change in levels of selenium in Sacramento River at Mallard Island (0.21 and 0.30 mg/L), when compared to the existing conditions (0.21-0.25 mg/L). However, the transect data for the North San Francisco Bay TMDL (in preparation) indicate that measured selenium concentrations at Mallard Island could be lower than 0.1 mg/L, hence, the existing conditions in the analyzed scenarios are set too high. Moreover, the benchmarks used to evaluate impact of selenium on fish and aquatic birds may not be fully protective of the most sensitive species. For many years now, these concentrations have been questioned by scientists and agency staff as being too high for protection of some species, and especially the benthic fish such as white sturgeon and green sturgeon that are most vulnerable to selenium exposure. This prompted the US EPA to start work on derivation of the site-specific objectives for San Francisco Bay and California. Based on the work to date, it appears that to prevent bioaccumulation of selenium to toxic levels in sturgeon the water column concentrations must be at levels well below 0.25 mg/L that were used in the impact analysis. To the extent possible these potential impacts should be stated and evaluated in the EIR/EIS to allow for future more detailed analyses once the proposed new fish tissue criteria are announced. We intend to work collaboratively with the proponents of the EIR/EIS/S to fully address this issue.	
2	8-17	2-27	8.1.1.7 Water Quality Impairments section of the EIR/EIS/S does not clearly state that Suisun Marsh wetlands are listed on the 2010 303(d) list as impaired for low DO/organic enrichment, mercury, nutrients and salinity. As a result the impacts that are likely to change DO conditions, nutrient concentrations or mercury levels	

			are not fully realized or considered in the document. Only effects of changes in salinity levels are considered in detail. Please include this information in the document.	
3	8-108	9-23	The EIR/EIS describes the Clean Water Act Section 401 Water Quality Certifications, Clean Water Act Section 404 and Rivers and Harbors Act Section 10109. The project description provided for CM 1 in the BDCP should be consistent with the project description provided in the Clean Water Act Section 404/Rivers and Harbors Act Section 10 and Clean Water Act Section 401 Water Quality Certification application(s). The project description for the BDCP should be expanded to include clarification at the proposed geographical locations(s) for: modification of any transportation and/or utility routes, and/or levee systems to accommodate the construction and implementation of the proposed project; (2) estimated acreage and/or linear feet in impacts to waters of the United States, including, but not limited to, modifications of transportation and utility routes, and/or levee systems; physical project components (i.e., pump intakes, pumping plants, pipelines, tunnels and tunnel alignments, canals, forebays, concrete batch plants, fuel stations, barriers and gates); and operational components; (3) volume (cubic yards) and anticipated frequency of sediment removal activities; and (4) areal extent and anticipated frequency of vegetation removal and revegetation activities.	
4	8-54	15-19	The environmental evaluation for the project anticipates a cumulative adverse impact with respect to mercury contamination. Conservation Measure 12 is designed to reduce adverse impacts caused by Conservation Measures 2, 4, 5, and 10, which are associated with wetland and floodplain habitat restorations. Mitigation measures include, but are not limited to, conforming to the relevant requirements of the Delta Mercury Control Strategy and the Central Valley Regional Water Control Board Basin Plan such as: required participation in efforts to minimize risks to human consumers of contaminated fish, participation in monitoring methylmercury loading from wetlands, and implementing appropriate and site-specific methylmercury control measures. The analyses acknowledge that mercury and methylmercury control measures are still in development, and it assumes that all practical measures will be implemented if reasonable and feasible. The analyses anticipate that not all contributions of methylmercury can be mitigated, and that even after all feasible mitigation measures are implemented, some adverse cumulative impacts may	

			remain. No adverse impacts with respect with mercury contamination were found in the upstream project areas, however, adjustments to water management in upstream reservoirs may influence mercury transport, methylmercury production, and methylmercury bioaccumulation in reservoirs and downstream of reservoirs. Reservoir creation and operation has been shown to create local hotspots of mercury methylation and bioaccumulation. Some of the factors that have been found to likely influence methylmercury production or fish methylmercury bioaccumulation in California reservoirs include: reservoir depth, temperature, thermal stratification and hypolimnetic anoxia, water level fluctuations, aqueous and sediment inorganic mercury and methylmercury concentrations, chlorophyll-a concentrations, and specific conductivity (Louie et al. 2012; Negrey et al. 2012). Fish mercury levels have been found to be statistically proportional to the amount of land flooded and the ratio of surface area to volume flooded in reservoirs in the United States and Canada (Bodaly et al. 2007; Johnston et al. 1991; Selch et al. 2007). The magnitude of reservoir water level fluctuations have been identified worldwide as an important factor in determining fish mercury levels (Evers et al. 2007; Roulet et al. 2001; Sorensen et al. 2005). A similar relationship has been found in California reservoirs, where a statistically significant positive correlation has been observed between California reservoir fish mercury concentrations and annual mean reservoir fluctuations (Louie et al. 2012). If the magnitude and timing of reservoir releases increase the magnitude of reservoir level fluctuations in project reservoirs, then this could result in increased mercury contamination in Central Valley Project and State Water Project reservoirs. Staff recommends that the EIR/EIS address the potential changes to mercury and methylmercury in the upstream project areas and work with Water Board staff on needed measures to address mercury related concerns. References: Bodaly, D., W. Jansen, A. Majewski, R. Fudge, N. Strange, A. Derksen, and D. Green. 2007. Postimpoundment Time Course on Increased Mercury Concentrations in Fish in Hydroelectric Reservoirs on Northern Manitoba, Canada. Archives of Environmental Contamination and Toxicology, 53: 379-389. Evers, D., Y. Han, C. Driscoll, N. Kamman, M. Goodale, K. Lambert, T. Holsen, C. Chen, T. Clair, and T. Butler. 2007.	
--	--	--	---	--

			Biological Mercury Hotspots in the Northeastern United States and Southeastern Canada. <i>Bioscience</i>, 57(1): 29-43. Johnston, T., R. Bodaly, and J Mathis. 1991. Predicting Fish Mercury Levels from Physical Characteristics of Boreal Reservoirs. <i>Canadian Journal of Fisheries and Aquatic Sciences</i>, 48: 1468-1475. Louie, S., M. Wood, and C. Austin. 2012. Development of a Statewide Mercury Control Program for Reservoirs. Poster Presentation Abstract, 7th Biennial Bay-Delta Science Conference. Sacramento, California., Available at: http://scienceconf.deltacouncil.ca.gov/content/poster-abstracts Negrey, J., W. Heim, M. Stephenson, and K. Coale. 2012. Mercury in California Lakes and Reservoirs: Factors Influencing Bioaccumulation in Black Bass. . Poster Presentation Abstract, 7th Biennial Bay-Delta Science Conference. Sacramento, California., Available at: http://scienceconf.deltacouncil.ca.gov/content/poster-abstracts Roulet, M., J. Guimaraes, and M. Lucotte. 2001. Methylmercury Production and Accumulation in Sediments and Soils of an Amazonian Floodplain – Effect of Seasonal Inundation. <i>Water, Air, and Soil Pollution</i>, 128: 41-60. Selch, T., C. Hoagstrom, E. Weimer, J. Duehr, and S. Chipps. 2007. Influence of Fluctuating Water Levels on Mercury Concentrations in Adult Walleye. <i>Bulletin of Environmental Contamination and Toxicology</i>, 79: 36-40. Sorensen, J. A., L. W. Kellemeyn, and M. Sydor. 2005. Relationship between mercury accumulation in young-of-the-year yellow perch and water-level fluctuations. <i>Environmental Science and Technology</i> 39:9237–9243.	
5	8-146	38	The EIR/EIS states: “For the assessment of Alternatives 1–9, the Sacramento River at Emmaton compliance location is relocated to Three Mile Slough near the Sacramento River. For comparing effects of the alternatives on EC in this portion of the Delta, changes in EC in Three Mile Slough under the alternatives are compared to EC at Emmaton under Existing Conditions and the No Action Alternative.” Three Mile Slough is approximately four miles upstream of Emmaton. Using different compliance location for the baseline than for the alternatives provides an	

			incomplete basis for comparison. Please provide comparable analyses and provide the scientific basis for this proposed change demonstrating that it provides equal or greater levels of protection. The State Water Board suggests using Emmaton as the compliance location in the modeling for all of the alternatives and then proposing separately, with scientific justification, that the compliance point be moved upstream.	
6	8-411 and 8-421	All	Impacts WQ-7 & WQ-11 for preferred Alternative 4 conclude that the BDCP may cause unavoidable adverse impacts to chloride and EC levels in the Delta and Suisun Marsh, which may increase the frequency of D1641 objectives violations and may be detrimental to municipal, agricultural, and fish & wildlife beneficial uses of water. The D-1641 requirements are legally binding for the protection of multiple beneficial uses of Delta water. If violating these standards is an unavoidable impact of the project, then the project proponents will need to work with the State Water Board to (1) demonstrate that the beneficial uses can be adequately protected by other means and (2) amend the Bay-Delta Plan and water rights requirements accordingly in coordination with the change petitions and other needed approvals for the project required from the Water Boards.	
7	App. 8H	All	The San Joaquin River compliance locations at Jersey Point and Prisoners Point are identified as being FWS objectives. The document should note that these objectives are also part of the Bay-Delta Plan and D-1641 and should be identified as such.	
8	8-172 to 8-723	6-42 All	The EIR/EIS should consider storage, management and disposal of wash water from concrete batch plants and associated equipment washing. Concrete wash water typically has very high pH, high salinity, and concentrations of dissolved metals (primarily hexavalent chromium) that could cause significant water quality impacts. If exposed to the environment, the solids that settle from concrete wash water may continue to leach alkalinity, dissolved solids, and/or dissolved metals after the water has been decanted. Although it identifies potential batch plant locations, the EIR/EIS does not provide specific details regarding the volume of concrete that would be used at each batch plant, nor does it discuss how the resulting wastewater and residual solids would be managed or disposed of. Wherever practical, generation of concrete wash water should be minimized and the wash water should be	

			recycled within the batch plant. It should not be discharged to either surface waters or land for disposal purposes, and short-term settling or storage containment features should be engineered to prevent percolation of the waste. For example, Caltrans' <i>Construction Site Best Management Practices Manual</i> standard storm water best management practices (BMPs), specifically BMP WM-8 (Concrete Waste Management), has been found to be adequate to protect surface water quality. With some additional modification to the wash water containment system design and operation, strict adherence to BMP WM-8 would also protect groundwater quality at the batch plant site. Specifically, we recommend the following: 1. Increasing the thickness of the wash water containment sump's polyethylene liner to 40 mils to improve liner durability; 2. Frequent (daily) decanting of liquid from the lined impoundment to a leak-free tank or bin for recycling in the batch plant; and 3. Providing a paved (or plastic-lined) and bermed area for curing waste or rejected concrete until the material has cured in place for at least one week. The Central Valley Water Board would regulate these facilities under Waste Discharge Requirements or a Conditional Waiver of Waste Discharge Requirements. The project proponent should plan to submit a Report of Waste Discharge at least one year prior to beginning this type of construction. In order to support adoption of WDRs or a waiver, the EIR/EIS should disclose (in general terms) the volume of concrete and Portland cement-based grout that the project would utilize for each type of construction; the expected volume of wash water per unit of concrete (e.g., gallons per 100 cubic yards); the methods of wash water containment and disposal that might be utilized; and the method(s) of residual solids handling, storage, and disposal. If recycling the wash water is not a viable option, the EIR/EIS should also discuss the expected chemical character of the waste with respect to pH, total dissolved solids, hexavalent chromium and other dissolved metals; and the methods of containment, treatment, and disposal that might be utilized.	
9	8-172 to 8-723	6-42 All	The EIR/EIS should consider storage, management and disposal of dewatering waste that has contacted uncured concrete or other cementitious materials. The construction of concrete structures involving placement of concrete in-stream or below the water table can generate dewatering waste that is similar in character to	

			concrete wash water. The EIR/EIS does not provide specific details regarding construction staging areas, the number of and type of subsurface concrete structures, or the volume of concrete that would be used, nor does it discuss how the resulting wastewater and residual solids would be managed or disposed of. Depending on the volume of water generated at each location, it may be possible to neutralize the water and then discharge to land discharge for disposal without causing significant impacts to water quality. Small discharges of this type could be regulated under the State Water Resources Control Board's <i>Statewide General Waste Discharge Requirements for Discharges to Land with a Low Threat to Water Quality</i> (Water Quality Order 2003-0003-DWQ or subsequent general WDRs order). In general, short-term containment should be provided to allow for pH testing and addition of the minimum required dose of neutralizing agent prior to discharge. If the waste will be discharged to land not owned by the state, the landowner's permission must be obtained. The Executive Officer of the Central Valley Water Board can authorize coverage under the Statewide General WDRs. The project proponent should plan to submit an application for coverage (known as a Notice of Intent) at least 90 days prior to beginning this type of construction. Larger discharges of dewatering waste contaminated by contact with uncured concrete may require additional treatment to reduce the concentration of dissolved metals and/or carefully controlled discharge, and individual Waste Discharge Requirements adopted by the Central Valley Water Board may be needed. The project proponent should plan to submit a Report of Waste Discharge at least one year prior to beginning this type of construction. In order to support coverage under the statewide general WDRs or adoption of individual WDRs or a waiver, the EIR/EIS should disclose (in general terms) the number of underground concrete structures that may require underwater placement on concrete; the expected volume of contaminated dewatering waste per location; the expected chemical character of the waste with respect to pH, total dissolved solids, hexavalent chromium and other dissolved metals; and the methods of containment, treatment, and disposal that might be utilized.	
--	--	--	---	--

10	8-469 8-470 8-473	25-26 35 10-13	The EIR/EIS should consider storage, management and disposal of water from construction dewatering. The EIR/EIS does not provide specific details regarding construction staging areas, the number of and type of excavations or in stream structures that would require dewatering during construction nor does it discuss how the resulting wastewater and residual solids would be managed or disposed of. Dewatering discharges to land often pose little or no threat to groundwater quality. However, the EIR/EIS should consider the possibility that excavation may encounter groundwater that has been polluted by leaking underground fuel storage tanks and spills of pesticides or other toxic or hazardous substances. Depending on the volume of water generated at each location, it may be necessary to treat the water prior to land disposal without causing significant impacts to water quality. Small, short term discharges of uncontaminated groundwater to land may qualify for coverage under the Central Valley Water Board's <i>Waiver of Reports of Waste Discharge and Waste Discharge Requirements for Specific Types of Discharge within the Central Valley Region</i> (Resolution R5-2008-0182 or subsequent general waiver). Longer term discharges or those that require treatment prior to discharge could be regulated under the State Water Resources Control Board's <i>Statewide General Waste Discharge Requirements for Discharges to Land with a Low Threat to Water Quality</i> (Water Quality Order No. 2003-0003-DWQ or subsequent general order). In general, short-term containment should be provided to allow for testing and treatment if required prior to discharge. If the waste will be discharged to land not owned by the state, the landowner's permission must be obtained. The Executive Officer of the Central Valley Water Board can authorize coverage under the Statewide General WDRs, and the project proponent to should plan to submit an application for coverage (known as a Notice of Intent) at least 90 days prior to beginning this type of construction. Very large or long term/permanent dewatering discharges to land may require individual Waste Discharge Requirements adopted by the Central Valley Water Board. The project proponent should plan to submit a Report of Waste Discharge at least one year prior to beginning this type of discharge.	
----	-------------------------	----------------------	--	--

			In order to support coverage under the statewide general WDRs, coverage under the low threat waiver, or adoption of individual WDRs, the EIR/EIS should disclose (in general terms) the number and type of excavations that may require dewatering; the expected volume of dewatering waste per location; the expected chemical character of the waste with respect to any known or suspected contaminants; and the methods of containment, treatment, and disposal that might be utilized.	
11	8-469 8-673	41-46 31	The EIR/EIS does not provide details on how much material from the various options under consideration, will be classified as dredge spoils. This designation applies to material removed below the Mean High Water (MHW) tidal datum. Material classified as dredge spoils will require Waste Discharge Requirements (WDR's) for the removal, upland placement (including both temporary dewatering sites and long-term placement or disposal sites) and/or subsequent reuse. Dredged material removed by hydraulic cutterhead suction requires large dewatering ponds, and any discharge of the clarified slurry water will be regulated under the terms of the WDR to prevent water quality impacts to surface waters. Dredged material placement on land must satisfy the criteria of being inert waste, in the placement location. Material not classified as inert requires the installation of liners and/or other impervious barriers according to Title 27 guidelines for the protection of groundwater and/or surface waters. Pre-dredge sediment characterization and placement site soil sampling is required in order to determine if the dredged material meets the criteria of being inert at the placement site location. Material should be tested for leachable constituents, acid generation potential, and other constituents of concern that may be identified as being present. Approval of dredging WDR's by the Central Valley Regional Water Quality Control Board in a public hearing (scheduled approximately every two months), requires submittal of a complete Report of Waste Discharge (ROWD) a minimum of 4-6 months prior to the scheduled Board meeting. Currently no dredging General Order permits are in place to cover new-work projects of this nature.	
12	8-469	23-29	Material will be excavated according to the various options under consideration in the EIR/EIS. There are potential water quality issues at the point of excavation,	

			and at storage, disposal and reuse areas. Potential waste issues include: (1) Runoff of water from excavated materials to surface waters, which is discussed separately under NPDES Permits; (2) Percolation of water into groundwater. If the percolating water is similar to underlying groundwater, there may not be a water quality issue. However if the excavated material contains saline water or other contaminants, there may be a potential for pollution of underlying groundwater. The chemical and physical properties of the excavated materials will need to be assessed relative to the potential for groundwater impact. Waste Discharge Requirements may be needed to prevent groundwater pollution dependent upon the characteristics of the excavated material and the site conditions at the storage, reuse or disposal area; and if the excavated material has the potential to generate acidic conditions after excavation, the acidic conditions may dissolve metals and other materials in the soils that are normally insoluble, and thus not a groundwater threat. The acid generation potential of excavated materials must be assessed to determine if Waste Discharge Requirements are needed, and whether measures must be taken to prevent groundwater pollution. Dredged material placement on land must satisfy the criteria of being inert waste, in the placement location. Material not classified as inert requires the installation of liners and/or other impervious barriers according to Title 27 guidelines for the protection of groundwater and/or surface waters. Pre-excavation soil characterization and placement-site soil sampling is required in order to determine if the dredged material meets the criteria of being inert at the placement site location. Material should be tested for leachable constituents, acid generation potential, and other constituents of concern that may be identified as being present. Approval of WDR's by the Central Valley Regional Water Quality Control Board in a public hearing (scheduled approximately every two months), requires submittal of a complete Report of Waste Discharge (ROWD) a minimum of 4-6 months prior to the scheduled Board meeting. Currently no General Order permits are in place to cover new-work projects of this nature.	
13	8-108	9-23	USEPA regulations (NPDES, TMDL, Title 27, Non-15, etc.) require that certain types of industrial activity have an NPDES Industrial Stormwater Permit. Such activities	

			include corporation yards, equipment storage and maintenance areas, materials storage areas, and manufacturing facilities, such as concrete batch plants. Whether or not permit coverage is needed depends on the type of activity, size of the facility, and whether those activities have the potential of adding pollutants to stormwater runoff. The remainder of this comment addresses concrete batch plants specifically, but similar comments are applicable to a wide variety of industrial activities that could be part of the project. The draft EIR/EIS notes that temporary concrete batch plants may be used at various locations to support project construction. Storm water runoff from industrial concrete batch plant sites has the potential to carry industrial pollutants such as metals, suspended solids, oil and grease, and high pH water to surface and ground water. Concrete wash water typically has very high pH, high salinity, and concentrations of dissolved metals (primarily hexavalent chromium) that could cause significant water quality impacts. If exposed to the environment, the solids settling from concrete wash water may continue to leach alkalinity, dissolved solids, and/or dissolved metals after the water has been decanted. Batch plants are one of the many types of industrial activities required by federal Clean Water Act to obtain coverage under an NPDES permit for storm water discharges. In California, NPDES permit coverage for industrial sites is available through the State Water Board's <i>General Industrial Activities Storm Water Permit, Water Quality Order No. 97-03-DWQ</i> (Industrial General Permit or IGP). Please note that a new Industrial General Permit is in preparation at the State Water Board, and it may include additional or modified requirements than the current permit. Operators of industrial batch plants follow a site -specific Storm Water Pollution Prevention Plan (SWPPP) and monitoring program to identify sources of pollution that affect the quality of storm water discharges through grab sampling and visual observations. The SWPPP should include a description and implementation of best management practices (BMPs) to reduce or prevent pollutants in industrial storm water discharges. Good site management and properly installed BMPs reduce the amount of site related contaminants that will be discharged off an industrial site during rain events. Wherever practical, generation of concrete wash water should be minimized and the wash water should be recycled within the batch plant. It should not be discharged to either surface waters or land for disposal	
--	--	--	---	--

			purposes, and short-term settling or storage containment features should be engineered to prevent percolation of the waste. Containment and disposal of concrete waste and wastewater may be subject to other permit requirements from the Regional Board. Comments on those requirements are provided elsewhere. The EIR/EIS should address how the project proponent will comply with the IGP and how the batch plant wastewater and residual solids will be managed. Application for coverage under the Industrial General Permit is completed by submitting a complete Notice of Intent, site map, and the annual Industrial General Permit fee of \$1,359 to the State Water Board. Although a Waste Discharge Identification Number (WDID) is generally issued within two to three weeks after a complete NOI and attachments are submitted, the project proponent should allow adequate time to develop a SWPPP prior to applying for permit coverage.	
14	General		Section 401 water quality certifications are issued by the Regional Water Quality Control Boards, the State Water Resources Control Board's Division of Water Quality, and the State Water Board's Division of Water Rights. Each entity has certification authority as defined by the California Code of Regulations, §3855. •The Division of Water Quality is responsible for issuing water quality certifications for projects which may fall under the jurisdiction of more than one regional board. •The Division of Water Rights is responsible for issuing water quality certifications associated with one or more of the following: 1. An appropriation of water; 2. A hydroelectric facility, and the proposed activity requires a Federal Energy Regulatory Commission (FERC) license or amendment to a FERC license; or 3. Any other diversion of water for domestic, irrigation, power, municipal, industrial, or other beneficial use. •The Regional Boards are responsible for all other projects within their regions for which a discharge may occur. Required items for issuance of a Clean Water Act Section 401 Water Quality Certification are based on Sections 3836 and 3856 of Title 23 of the California Code of Regulations.	

			The project proponents should note that: (a) there are no waivers for Clean Water Act Section 401 Water Quality Certifications in the state of California; (b) a Clean Water Act Section 401 Water Quality Certification serves as both a certification, in part or in whole, of a federal permit, under Section 401 of the Clean Water Act, and as a Waste Discharge Requirement under the Porter-Cologne Water Quality Control Act; and (c) under Section 401 of the Clean Water Act, the state of California can review and approve, condition, or deny all federal permits that may result in a discharge to waters of the State, including wetlands. The Water Boards will work with the project proponents to assure that the 401 certifications are coordinated.	
15	8A1-19	All	Appendix 8A consists of some tables without titles or reference citations. Please include the source(s) of the information, and which locations or water bodies the tables are referring to.	
16	8-8, 8-9	30-41, 1-33	This Section 8.1.1.4 lists the primary factors that affect water quality within the Delta. Some of the listed factors include land use in the upstream watersheds and Delta, and SWP and CVP operations. Please include other factors that affect water quality, such as non-SWP/CVP diversions	

BDCP EIR/EIS Review Document Comment Form

Document: Administrative Draft—Chapter No. 9__ Geology and Seismicity

Comment Source: SWRCB

Submittal Date: 7/5/2013

No.	Page	Line #	Comment	ICF Response
			Possible comments to be provided on public draft	

BDCP EIR/EIS Review Document Comment Form

Document: Administrative Draft—Chapter No. 10__ Soils

Comment Source: SWRCB

Submittal Date: 7/5/2013

No.	Page	Line #	Comment	ICF Response
1			Possible comments to be provided on public draft	

BDCP EIR/EIS Review Document Comment Form

Document: Administrative Draft—Chapter No. 11 *Fish and Aquatic Resources*

Comment Source: SWRCB

Submittal Date: 7/5/2013

No.	Page	Line #	Comment	ICF Response
1	General		The EIR/EIS should provide an evaluation and comparison of changes to the quality and quantity of open water aquatic habitats and subsequent impacts on target fish populations under the alternatives, including changes in salinity gradients, dissolved oxygen levels and hydrodynamics.	
3	General		State Water Board staff reviewed the comments on the December 2012 Administrative Draft BDCP that were prepared by National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS), and the 2012 Red Flag comments on the February 2012 version of the BDCP Effects Analysis, that were submitted by the US Bureau of Reclamation (USBR) and the fishery agencies (California Department of Fish and Wildlife (CDFW), USFWS, and NMFS). Water Board staff support the fishery agencies' comments contained in these documents.	
4	General		The impact analysis does not appear to provide analysis for all decision tree scenarios (H1-H4). For instance, in the fish passage section, only scenarios H1, H3, and H4 were analyzed, while only H3 was analyzed in the water temperature section and upstream habitat section. If the detailed analyses provided in the document brackets the rest of the scenarios, a qualitative discussion should be provided that explains why the existing analyses brackets the impacts associated with the scenarios that did not undergo detailed analysis.	
5	General		The impacts for non-covered fish species appear to be copied from the impact summary for covered fish species. Please describe the basis for this analysis.	
6	General		The analysis assumes a specified construction schedule for assessing impacts to fishery and aquatic resources. Some of the impact analysis conclusions were based on assumptions regarding fish presence during the time of construction. It is not clear whether the analysis evaluates the potential impacts to fishery and aquatic resources associated with delayed construction schedules.	
7	General		The fishery and aquatic resources impact analysis does not appear to analyze scenarios in which conservation measures are not 100% successful.	

			Section 5.2 of the BDCP describes how the conservation measures were evaluated to determine if biological objectives could be met for covered fish. Table 5.2-8 of the BDCP indicates that out of the thirty-nine biological goals and objectives, only eleven could be assessed for feasibility, and fifteen could only be partially assessed for feasibility. However, the EIR/EIS appears to assume that all of the conservation measures will be successful in meeting biological goals and objectives. The lack of certainty regarding the success of the conservation measures should be a consideration in the impact analysis and significance determinations reported in the EIR/EIS.	
8	General		Significance thresholds are described on pages Part 1-11-117 and Part 1-11-118. These significance thresholds do not contain numeric values; however elsewhere in the text, the document refers to parameters such as "significance criterion", "upper tolerance threshold", and "level of biological significance". These appear to be numeric thresholds, but are not clearly identified. Please summarize the numeric thresholds that are used in the analysis, including the reasoning for the values chosen.	
9	General		Table 3.4.1-3 of the BDCP (pages 3.4-23 – 3.4-24) identifies four uncertainties associated with the North Delta Diversion Bypass Flows. These include: (1) Determine timing and rate of downstream passage by larval delta smelt, and effects on mortality; (2) Determine timing and rate of downstream passage by juvenile salmonids (all Chinook runs and steelhead), and effects on mortality; (3) Determine the effects of altered flows and resultant altered distribution and timing of salinity on dispersal and colonization by invasive species; and (4) Determine the effects of hydrodynamics near the intakes on behavior and energetics of covered fishes. These uncertainties appear to have potential for environmental impacts to aquatic species, but it is unclear whether these issues were examined in the EIR/EIS.	
10	Part 1, pages 11-114		The coldwater fish habitat analysis appeared to only analyze for impacts to fish living in reservoirs, and did not analyze for impacts to fish living downstream that may be dependent on reservoir releases. Please explain.	
11	Part 3, pages		Existing through-Delta (to Chipps Island) survival of juvenile salmon is estimated by the Delta Passage Model to be 16% – 28%, and does not change	

	11-75 and 11- 128		markedly under any of the Alternative 4 decision tree scenarios. However, the BDCP (Table 3.3-1, page 3.3-17) indicates the BDCP Biological Objective for through-delta juvenile salmon survival is approximately 45% (varies somewhat by ESU, river of origin, and planning horizon). Although the BDCP seems to indicate this biological objective can be achieved by utilizing conservation measures 1, 2, 4, 5, 6, 14, 15, 16, 19, and 21, analysis of estimated survival improvements was provided for only conservation measure 1. It is not clear how the biological objective for through-delta juvenile salmon survival will be achieved because no estimates of survival improvements were provided for the other conservation measures.	
12	Part 3, pages 240- 241		Significant decreases in the frequency of high spring Delta outflows are predicted under Scenario H3, which could impact sturgeon migration. Scenario H3 does not contain the enhanced spring outflow. However, the discussion of Scenario H4 (which does contain the enhanced spring outflow) states that no additional analyses are necessary because flows will be effectively the same under H4 as H3, except in May and June, when they will be lower under H4. It is unclear how this conclusion was reached, given that these two scenarios have very different spring outflow requirements.	
14	General		A better connection between the water quality chapter and the water quality issues addressed in chapter 11 should be provided. The discussion of temperature in Chapter 11 should identify any water bodies which have been 303(d) listed for temperature. This would include water bodies within the immediate Project area as well as those located in areas where water is delivered. This would be consistent with the information that is contained within the water quality chapter. Although temperature is discussed in Chapter 11, it is important that it is discussed in the same manner as other water quality constituents.	
15	General		The quality and quantity of aquatic habitat should be evaluated in the aquatic resources chapter and evaluated with respect to the impacts of the alternatives. Specifically, an analysis of impacts to open water habitat using 1D or preferably 3D modeling should be provided by evaluating changes in the salinity gradient (X2) and the change in area of preferred habitat for different species.	

BDCP EIR/EIS Review Document Comment Form

Document: Administrative Draft—Chapter No. 12—Terrestrial Biological Resources

Comment Source: SWRCB

Submittal Date: 7/5/2013

No.	Page	Line #	Comment	ICF Response
1	General		The aquatic habitat evaluation should be included in the aquatics chapter rather than the terrestrials chapter to allow for a complete evaluation of impacts.	
2	General		The EIR/EIS should provide historical frames of reference for impacts to natural communities in addition to comparisons with existing conditions.	
3	General		Here and other places in the document, aquatic natural community restoration appears to assume 100% success. Is there an assumption of a success rate for any of the restoration projects? If so, it would be helpful to disclose that assumption and detail support for it. If not, a discussion of the success rate among restoration projects for each of the natural communities is appropriate for providing the reader an understanding of the potential for restoration to be successful and reduce impacts.	

BDCP EIR/EIS Review Document Comment Form

Document: Administrative Draft—Chapter No. 13__ Land Use

Comment Source: SWRCB

Submittal Date: 7/5/2013

No.	Page	Line #	Comment	ICF Response
1			Possible comments to be provided on public draft	

BDCP EIR/EIS Review Document Comment Form

Document: Administrative Draft—Chapter No. 14__ Agricultural Resources

Comment Source: SWRCB

Submittal Date: 7/5/2013

No.	Page	Line #	Comment	ICF Response
1			Possible comments to be provided on public draft	

BDCP EIR/EIS Review Document Comment Form

Document: Administrative Draft—Chapter No. 15__ Recreation

Comment Source: SWRCB

Submittal Date: 7/5/2013

No.	Page	Line #	Comment	ICF Response
1			Possible comments to be provided on public draft	

BDCP EIR/EIS Review Document Comment Form

Document: Administrative Draft—Chapter No. 16__Socioeconomics

Comment Source: SWRCB

Submittal Date: 7/5/2013

No.	Page	Line #	Comment	ICF Response
1			Possible comments to be provided on public draft	

BDCP EIR/EIS Review Document Comment Form

Document: Administrative Draft—Chapter No. 17__Aesthetics and Visual Resources

Comment Source: SWRCB

Submittal Date: 7/5/2013

No.	Page	Line #	Comment	ICF Response
1			Possible comments to be provided on public draft	

BDCP EIR/EIS Review Document Comment Form

Document: Administrative Draft—Chapter No. 18__Cultural Resources

Comment Source: SWRCB

Submittal Date: 7/5/2013

No.	Page	Line #	Comment	ICF Response
1			Possible comments to be provided on public draft	

BDCP EIR/EIS Review Document Comment Form

Document: Administrative Draft—Chapter No. 19__Transportation

Comment Source: SWRCB

Submittal Date: 7/5/2013

No.	Page	Line #	Comment	ICF Response
1			Possible comments to be provided on public draft	

BDCP EIR/EIS Review Document Comment Form

Document: Administrative Draft—Chapter No.20 Public Services and Utilities

Comment Source: SWRCB

Submittal Date: 7/5/2013

No.	Page	Line #	Comment	ICF Response
1	20-29	16	The Methods for Analysis includes bulleted lists that include some of the sources that were used to collect information, such as GIS data for law enforcement and fire protection facilities, contact with service agencies, aerial photography, and State databases. The State Water Board's eWRIMS water rights database may be useful to the BDCP since the BDCP area includes many water right holders as well as water diverters.	
2	20-116	1-43	The EIR/EIS states that field offices and concrete batch plants may need as much as 47.5 million gallons of potable water. In addition, the document also states that the sites are often in rural areas where public hookups are not always available, although the document describes the trucking of needed water. The source(s) of the potable water and, if applicable, the water rights associated with the source(s) should be identified and potential impacts evaluated.	

BDCP EIR/EIS Review Document Comment Form

Document: Administrative Draft—Chapter No.21 Energy

Comment Source: SWRCB

Submittal Date: 7/5/2013

No.	Page	Line #	Comment	ICF Response
1	21-15	6	The EIR/EIS assumes that upstream impacts due to project alternatives are zero because upstream hydropower operations are controlled by runoff. The chapter provides little support of the assumption that upstream impacts to hydropower will be null. Changes in release patterns, and therefore generation patterns, could impact hydropower production, even if average annual flows through the powerhouses remain constant. For example shifts in generation from summer to spring represents an impact to generation, even if the volumes remain constant. Please clarify.	

BDCP EIR/EIS Review Document Comment Form

Document: Administrative Draft—Chapter No.22 __Air Quality and Greenhouse Gases

Comment Source: SWRCB

Submittal Date: 7/5/2013

No.	Page	Line #	Comment	ICF Response
1			Possible comments to be provided on public draft	

BDCP EIR/EIS Review Document Comment Form

Document: Administrative Draft—Chapter No.23 __Noise

Comment Source: SWRCB

Submittal Date: 7/5/2013

No.	Page	Line #	Comment	ICF Response
1			Possible comments to be provided on public draft	

BDCP EIR/EIS Review Document Comment Form

Document: Administrative Draft—Chapter No.24 __Hazards and Hazardous Materials

Comment Source: SWRCB

Submittal Date: 7/5/2013

No.	Page	Line #	Comment	ICF Response
1			Possible comments to be provided on public draft	

BDCP EIR/EIS Review Document Comment Form

Document: Administrative Draft—Chapter No.25 __Public Health

Comment Source: SWRCB

Submittal Date: 7/5/2013

No.	Page	Line #	Comment	ICF Response
1			Possible comments to be provided on public draft	

BDCP EIR/EIS Review Document Comment Form

Document: Administrative Draft—Chapter No.26 __ *Mineral Resources*

Comment Source: SWRCB

Submittal Date: 7/5/2013

No.	Page	Line #	Comment	ICF Response
1			Possible comments to be provided on public draft	

BDCP EIR/EIS Review Document Comment Form

Document: Administrative Draft—Chapter No.27 __ *Paleontological Resources*

Comment Source: SWRCB

Submittal Date: 7/5/2013

No.	Page	Line #	Comment	ICF Response
1			Possible comments to be provided on public draft	

BDCP EIR/EIS Review Document Comment Form

Document: Administrative Draft—Chapter No.28 __ *Environmental Justice*

Comment Source: SWRCB

Submittal Date: 7/5/2013

No.	Page	Line #	Comment	ICF Response
1			Possible comments to be provided on public draft	

BDCP EIR/EIS Review Document Comment Form

Document: Administrative Draft—Chapter No.29 __ *Climate Change*

Comment Source: SWRCB

Submittal Date: 7/5/2013

No.	Page	Line #	Comment	ICF Response
1	2	25	The EIR/EIS mentions that the BDCP analyzes possible sea level rise of up to 55 inches. However, reading the modeling appendices, the amount of sea level rise used in the effects analysis was only 17.7 inches. We understand that 55 inches is a year 2100 projection and that 17.7 inches was chosen instead to represent the modeling baseline, year 2060. However, the EIR/EIS should clarify in Chapter 29 (and also in Chapter 3 where the No Action Alternative is described) that the effects analysis used 17.7 inches of sea level rise rather than 55 inches. Otherwise, the document could mislead readers into thinking that 55 inches of sea level rise was analyzed throughout.	

BDCP EIR/EIS Review Document Comment Form

Document: Administrative Draft—Chapter No.30 __ *Growth Inducement*

Comment Source: SWRCB

Submittal Date: 7/5/2013

No.	Page	Line #	Comment	ICF Response
1			Possible comments to be provided on public draft	

BDCP EIR/EIS Review Document Comment Form

Document: Administrative Draft—Chapter No.31 __ *Other CEQA/NEPA Required Sections*

Comment Source: SWRCB

Submittal Date: 7/5/2013

No.	Page	Line #	Comment	ICF Response
1			Possible comments to be provided on public draft	

Attachment State Water Board Analysis of Alternatives and

Sacramento River and Delta outflows are controlled within the CALSIM II modeling of the BDCP by cold water constraints, North Delta bypass rules, Delta outflow, minimum flow at Freeport and EC requirements. This section focuses on differences in modeling assumptions and results under Alternative 4 and Alternative 8 of the BDCP EIR/EIS. Differences between Alternative 4 and 8 can be broken up into two separate categories; physical and operational which are summarized in the table below. Physically, the two are very similar; the primary difference relating to fisheries is the presence of the operable barrier at the Head of Old River (HORB) in Alternative 4, and absence in Alternative 8. There are many operational differences between the two alternatives including minimum Sacramento River bypass flows, minimum OMR flows, minimum Delta outflow, minimum San Joaquin River inflow and maximum export restrictions listed in the table below.

Summary									
Alternative	Conveyance	# North Delta Intakes	Capacity (cfs)	Operating Scenario	Avg Annual Exports	Fall X2 ³	OMR Protection ¹	South Delta Barriers	NMFS SJR E-I Ratio ²
Existing Cond.	No Improvements	0	NA	NA	5.1 MAF	No	BiOps	Yes	Yes
<i>Notes: Year 2009 development; Includes all projects ongoing as of Feb 2009 plus the Jun 2009 NMFS BiOp. Does not include Freeport Regional Water Project or CCWD's Victoria Canal Intake (both recently completed)</i>									
No Action	No Improvements	0	NA	NA	4.4 MAF	Yes	BiOps	Yes	Yes
<i>Notes: Year 2020 development; Full SWP & CVP build-out; Climate change; Sea level rise</i>									
4	Tunnel & Through-Delta	3	9,000	H	4.4 - 5.3 MAF	Maybe	Intermed.	Yes	No
<i>Alt 4 Notes: Operable Head of Old River Barrier; Gravity fed tunnel, Enhanced Spring Delta outflow (maybe)</i>									
8	Tunnel & Through-Delta	3	9,000	F	3.1 MAF	Yes	High	No	Enhanced
<i>Alt 8 Notes: Increased Delta outflow; Increased North Delta bypass flow; Coldwater pool management; 55% unimpaired flow at Freeport Jan - Jun³</i>									

¹ Source: Table C-9-6. Old and Middle River, Monthly Flow (combined flows)

² Source: Table C-7-2-16. Sacramento/San Joaquin River Delta, Monthly Outflow Volume

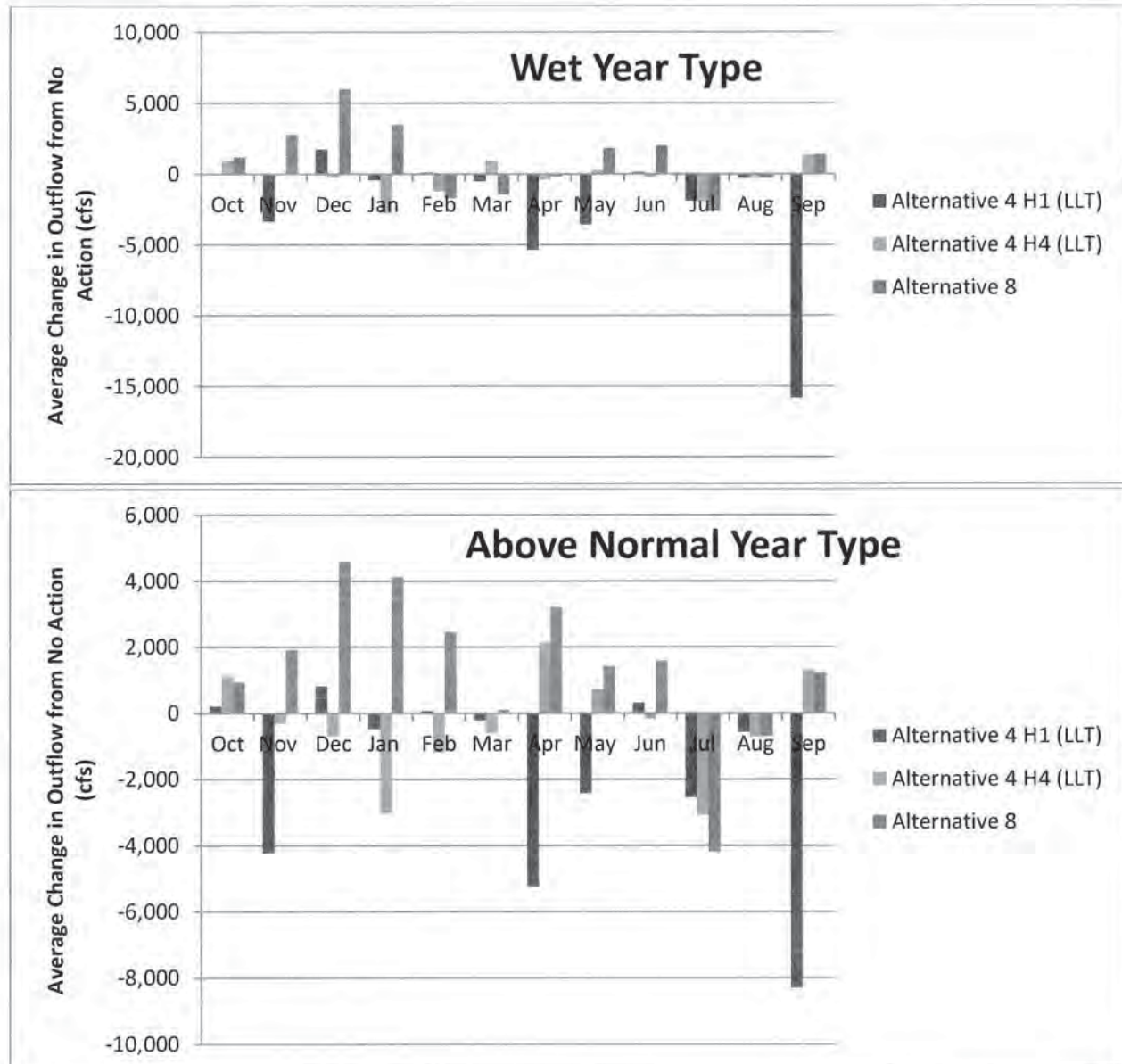
³ Source: Table C-7-1-1. Sacramento/San Joaquin River Delta, Monthly Outflow Rate

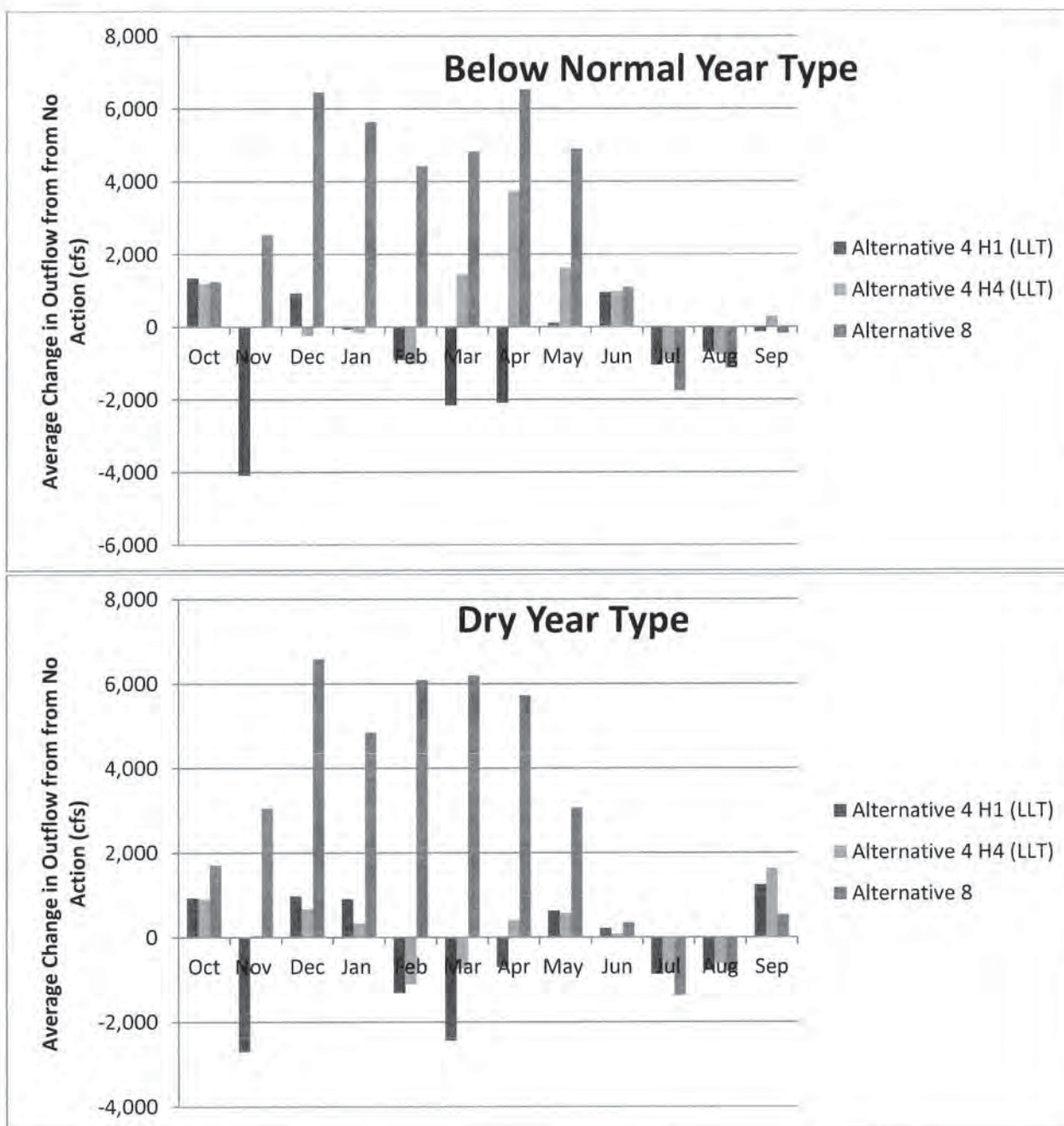
Delta Outflow

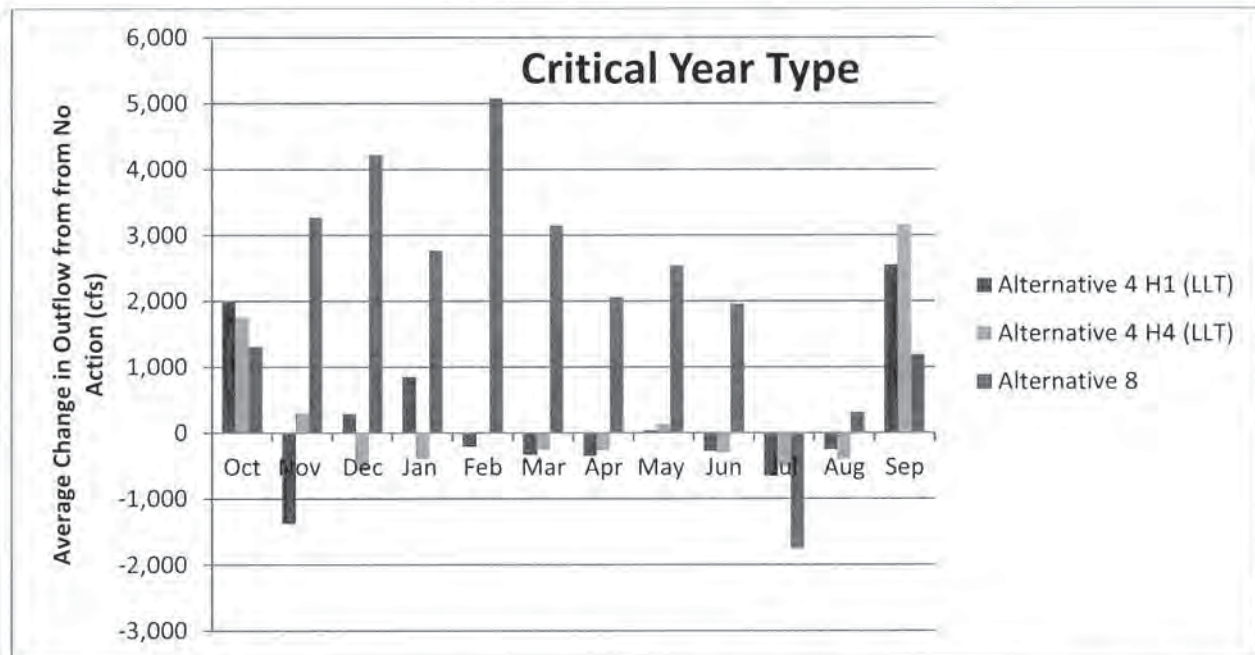
Delta Outflow for Alternative 4 has four different decision tree scenarios (H1-H4) ranging from D-1641 to enhanced spring and fall outflow. Delta outflow for Alternative 8 is based on D-1641 most of the year, plus fall X2 requirements and 55% unimpaired flow at Freeport (capped at 40,000 cfs) from January – June. The discussion here compares the most protective (H4) and least protective decision tree scenario (H1) with outflow for Alternative 8. Decision tree scenario H1 is identical with the current outflow conditions as set forth in D-1641. Decision tree scenario H4 outflow is D-1641 with Fall X2 and an “enhanced” March-May target that ranges from 9,200 cfs to 44,500 cfs based on percent exceedance of forecasted March-May eight river index. A large difference that should be noted is the length of time that the enhanced spring outflows cover; Alternative 8 covers 5 months whereas H4 covers only 3.

Below are CALSIM II results showing changes from No Action Alternative in average monthly outflow for each year type for scenarios H1, H4, and F. The wet year type shows very similar outflows for each of the scenarios which reflect the fact that the system is controlled in wet years by natural runoff. Unlike wet year types, however, there is a large difference in outflows between scenarios in critical years. Alternative 4 H1 (LLT) results in a decrease in outflow in November, February – April, June – August and particularly large increase in September and October. In critical year types, spring Delta outflow is lower under all Alternative 4 scenarios than the No Action Alternative which many studies have shown is the time when fishes currently need higher flows the most. The “enhanced” spring outflow only provides a significant increase in outflow in Below Normal year types which comprise of only 17% of the simulation period.

Possible explanations for the increase over No Action during the fall in Alternative 4 in Dry and Critical years could include increased flows to meet temperature requirements in the Sacramento River due to climate change or could be due to North Delta bypass restrictions, more clarification on why this occurs by the authors would be helpful.







Alternative minus No Action		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Ave
Alternative 4 H1 (LLT)	Full Simulation Period	753	-3,172	1,083	109	-433	-1,148	-3,028	-1,325	257	-1,446	-509	-5,613	-1,206
	Wet	-1	-3,336	1,736	-423	97	-512	-5,353	-3,574	139	-1,910	-308	-15,832	-2,439
	Above Normal	207	-4,231	816	-468	67	-213	-5,242	-2,417	320	-2,552	-570	-8,302	-1,882
	Below Normal	1,339	-4,093	923	-68	-910	-2,167	-2,098	110	942	-1,049	-700	-139	-659
	Dry	929	-2,705	972	902	-1,313	-2,439	-707	628	207	-874	-782	1,242	-329
	Critical	1,987	-1,379	288	852	-205	-332	-345	37	-276	-655	-251	2,549	189
		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Ave
Alternative 4 H4 (LLT)	Full Simulation Period	1,130	-10	-160	-1,338	-978	257	867	617	42	-1,487	-527	1,483	-8
	Wet	966	-51	-261	-2,778	-1,222	944	-438	275	-240	-1,949	-308	1,328	-311
	Above Normal	1,132	-315	-693	-3,029	-1,193	-613	2154	729	-168	-3,087	-713	1,314	-374
	Below Normal	1,190	-8	-241	-177	-1,025	1448	3743	1625	984	-920	-766	289	512
	Dry	905	45	678	332	-1,111	-736	409	580	83	-840	-619	1,630	113
	Critical	1,752	306	-571	-389	20	-258	-265	128	-299	-519	-399	3,164	223
		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Ave
Alternative 8	Full Simulation Period	1,291	2,749	5,742	4145	2650	2204	3091	2668	1415	-2,307	-527	870	2,000
	Wet	1,178	2,796	6,003	3490	-1716	-1441	-167	1827	1989	-2,625	-308	1,358	1,033
	Above Normal	941	1,914	4,583	4137	2449	103	3210	1422	1596	-4,208	-710	1,224	1,388
	Below Normal	1,247	2,530	6,463	5641	4420	4836	6531	4895	1093	-1,760	-1,134	-182	2,881
	Dry	1,711	3,060	6,592	4850	6095	6196	5727	3068	350	-1,376	-809	536	3,000
	Critical	1,310	3,270	4,223	2769	5076	3147	2060	2540	1958	-1,749	313	1,189	2,176

Source: Appendix 5A Modeling, pg C-184 - C-192

FOR IMMEDIATE RELEASE

Media contact: Serena Ingre, singre@nrdc.org or 415-875-6155

New Plan Offers an Effective, Affordable Package of California Water Supply and Bay-Delta Fisheries Solutions

SAN FRANCISCO, CA (January 16, 2013) Investing in a broad portfolio of Bay-Delta water solutions can save Californians billions of dollars in costs while increasing water supply and strengthening protections for the ailing delta ecosystem and its fisheries, according to a new proposal released today by business and conservation groups in advance of the draft Bay Delta Conservation Plan expected next month. The Bay-Delta is the largest estuary in the West and a critical source of water supply for more than 22 million Californians.

This is the kind of fresh approach that is needed to protect the Bay-Delta environment, state taxpayers, and meet California's water needs, said **Congressman George Miller (D – Concord)**. I know how powerful it can be when thoughtful environmentalists, business leaders and urban water agencies reach common ground on the water solutions that are so critical to our state's future.

The proposal, *A Portfolio-Based Conceptual Alternative for the Bay Delta Conservation Plan*, offers a more effective and affordable package of solutions to address the complex water challenges facing the delta today. The alternative plan proposes focusing on a smaller, less expensive new water conveyance tunnel in the delta, and investing the cost savings in water recycling and conservation to meet the long-term water needs of cities and farms. Additional savings could be used to shore up the delta's aging levees and to increase water storage south of the delta. Collectively, this package of solutions would cost billions of dollars less than the \$18 billion price tag for the current draft Bay Delta Conservation Plan that is narrowly focused on a much larger set of twin tunnels and habitat restoration.

A group of conservation and business groups, including **The Bay Institute**, the **Contra Costa Council**, **Defenders of Wildlife**, **Environmental Entrepreneurs**, the **Planning and Conservation League** and the **Natural Resources Defense Council**, sent a [letter](#) urging U.S. Interior Secretary Ken Salazar, Secretary John Laird, Deputy Secretary Jerry Meral and Commissioner Michael Connor to consider seriously this alternative as they move forward to finalize the plan for the future of the delta. Separately, **San Diego Mayor Bob Filner** and a group of urban water agencies, including **Contra Costa Water District**, **East Bay Municipal Utility District**, **Alameda County Water District**, **San Francisco Public Utilities Commission**, **San Diego County Water Authority** and **Otay Water District** also sent a joint [letter](#) in support of careful analysis of this new proposal.

By reducing the size and cost of a delta facility and habitat restoration, the proposal shows that billions of dollars could be saved and invested in a range of proven, cost-effective regional water solutions, including:

- **Dramatically increasing local water recycling and conservation:** Boosts water supply overall and improves the reliability of water in dry years by investing in local solutions south of the delta.
- **Reinforcing delta levees:** Reduces vulnerability to earthquakes, sea level rise and climate change impacts.
- **Improving cooperation among water agencies:** Strengthens collaboration among water agencies to maximize the benefits of water recycling and groundwater management to provide new water supplies at lower costs.
- **Developing new water storage south of the delta:** Improves our ability to store water in wet years to meet needs in dry years when high delta pumping levels can be most harmful.

The many potential benefits of these investments include more water at a lower cost in comparison with the current draft BDCP plan, a healthier environment, thousands of new jobs in the communities that would pay the majority of costs, greater likelihood of permitting from regulators, greater potential to attract funding partners and reduce pressure for public funding, faster water supply benefits; more local control of water supply, and less reliance on imported water.

The plan recommends restoring 40,000 acres of delta habitat, driven by the best available science to protect native fish and wildlife, over the next 15-20 years. Although ambitious, this restoration program would be a reduction from what is proposed in the current draft BDCP plan, and focused on the near term, which is when habitat restoration needs to occur.

This conceptual alternative also relies on proposed water flow and pumping rules developed by state and federal fisheries agency scientists to protect the delta and its fisheries, based on the best science available today. In these and several other areas, however, additional analysis of costs and benefits is needed to optimize this new approach.

Up to now, the Bay Delta Conservation Plan has focused largely on advancing a massive twin tunnel conveyance facility along with a very large scale habitat restoration effort. This approach could be burdened with large uncertainties, including impacts on imperiled species, uncertainty about future water supplies, open-ended costs to water agencies and the public, as well as heightened political controversy.

Following are statements from conservation and business groups in support of this conceptual alternative for the Bay Delta Conservation Plan:

It is essential we find long-lasting solutions for the Delta, said **Bob Whitley, co-chair Water Task Force at the Contra Costa Council**. The solutions we put on the table must strengthen protections for the delta ecosystem and be financially viable so we can meet the water demands of all within our means.

In the investment community, it is accepted wisdom that a diversified portfolio is a wise strategy to minimize risk and obtain an acceptable return, said **Barry Nelson, senior policy analyst with the Natural Resources Defense Council**. The alternative plan set forth today uses a comprehensive approach to show how we can produce improved water supplies and a healthier Bay-Delta at a lower cost. This is the kind of integrated, science-based and economically sound approach that is needed to break the logjam in the delta debate and demonstrate that a healthy environment and a healthy economy go hand in hand.

If this proves out, it will be an affordable end to decades of California water wars, said **Jonas Minton, water policy advisor at the Planning and Conservation League**.

It is imperative that the BDCP succeed and deliver reliable water for California and reliable conservation for our declining Bay Delta fish and wildlife, said **Kim Delfino, California director at Defenders of Wildlife**.

We are asking the agencies to analyze this alternative because we believe that the information gained will be critical in picking a winning plan.

It's impossible to solve the Delta's problems without looking outside the Delta to put in place the water management strategies that ensure California uses its finite water resources more wisely, said **Gary Bobker, program director at The Bay Institute**. The beauty of this alternative is that for the first time it links what we do in the Delta to how we manage water throughout the state.

For more information on the alternative plan released today, see the following links:

- Complete alternative proposal: <http://bit.ly/13E0xsi>
- Letter from business and conservation groups: <http://bit.ly/Ut0SKs>
- Letter from San Diego Mayor Bob Filner and urban water agencies: <http://bit.ly/W0JI8x>

- Conceptual alternative portfolio approach illustration: <http://bit.ly/W7kB0V>
- Current BDCP approach illustration: <http://bit.ly/X8nu0C>
- NRDC Kate Poole s blog: <http://bit.ly/XeNjwQ>
- NRDC Barry Nelson s blog: <http://bit.ly/SLmnbU>

Additional media contacts:

Bob Whitley, Contra Costa Council, 925-963-6533

Gary Bobker, The Bay Institute, 415-272-6616

Kim Delfino, Defenders of Wildlife, 916-201-8277

Jonas Minton, Planning and Conservation League, 916-719-4049

###

A Portfolio-Based BDCP Conceptual Alternative

The eight components described below represent a conceptual alternative, not a proposed BDCP project. The analysis of this alternative is intended to assist BDCP in developing the most cost-effective and environmentally beneficial final BDCP project that can be implemented and produce benefits rapidly. Variations on the approaches below should be analyzed as well, including a full range of conveyance capacities.

Guiding Principles

Science-Based Ecosystem Management: Credible, proven science will determine ecosystem improvements and water management, using on-the-ground results as the central driver of decision-making.

Water Supply Reliability: The BDCP can contribute to improved water supply reliability by reducing the physical vulnerability of Delta water supplies and embracing a portfolio approach that recognizes that water suppliers and the public have a broad range of options both in and outside of the Delta to meet their water needs and improve reliability.

A Strong Business Case: A strong business case is central to the success and financial viability of the BDCP. Sound economic principles and cost-benefit analysis must inform water supply improvements so that water ratepayers understand that the benefits they will receive from the project are reasonably proportional to what they are being asked to pay.

Water Quality: Delta water quality will be strongly influenced by the final BDCP plan, with potential impacts and benefits to export water users, local municipalities, Delta residents, Delta farmers and the ecosystem.

Conceptual Elements of a Diversified Portfolio Approach

New Conveyance Facility: Focus BDCP analysis on one 3,000 cfs North Delta intake facility and a single tunnel sized for 3,000 cfs gravity flow. This smaller facility would lower BDCP costs, improve reliability and reduce opposition. If implementation proves successful in meeting biological goals and objectives, a second phase could be constructed subsequently, but would not be permitted at this time.

Project Operations: Analyze, as a starting point for analysis of future SWP and CVP operations, the best science available today. In particular, analyze the operations proposal developed by state and federal biologists to conserve and manage a full range of covered Delta fish species, including consideration of the need to protect upstream fisheries resources.¹ Project operations should utilize a “big gulp, little sip” approach that increases exports in wet years – when water is available in excess of environmental needs

¹ The work of state and federal agency biologists to produce a science-based operational scenario is summarized on pages 1-16 of this BDCP presentation - http://www.essexpartnership.com/wp-content/uploads/2012/11/BDCP_CS5_Update_NGO-Meeting_11_14_12v3.pdf

– and reduces diversions in average and drier years, particularly during key periods such as the spring and fall. Such an operations proposal has been developed over the past year by state and federal fish agency biologists. This is an important agency analysis that should be subjected to additional refinement in an open, transparent process, utilizing independent external peer reviewers. It is essential not to delay a detailed analysis of the likely yield of a new facility based on the best available science.

Estimated Water Exports: ~ 4 - 4.3 MAF/ year (2025). This is an initial estimate of average exports. BDCP has not yet modeled a 3,000 cfs facility with additional South of Delta storage and the agency-developed operational scenario included in this proposal.

Reduced Reliance on the Delta through Investments in South of Delta Water Supplies: DWR, many Urban Water Management Plans and other analyses have concluded that local water supply tools including conservation, water recycling, and other approaches, can provide reliable, sustainable and plentiful new sources of supply that will also be cost-effective over the long run. These sources can also be provided rapidly through additional investments. There is approximately as much new water available from these new water supply sources as is currently exported from the Delta.

This conceptual alternative proposes a smaller capital investment in a Delta facility, in comparison with the current BDCP preliminary project, and investment of savings in local water supply projects. For analytical purposes, this alternative includes a \$2 billion investment in water recycling (at a capital cost of approximately \$6,430 - 6,470 per AF of permanent water recycling capacity) and a \$3 billion investment in urban conservation (at an initial/capital cost of \$3,230-4,860 per AF).² Urban stormwater capture, groundwater cleanup, and conjunctive use should be included as cost-effective methods for generating future new sources of water, and would also be important elements of a large-scale effort to invest in new local water sources. Additional cost-effective savings can also be obtained from investments in agricultural conservation.³

Estimated Yield: 926,000 - 1,245,000 acre-feet of permanent water supply. (309,000 – 311,000 acre-feet from water recycling and 617,000 - 934,000 acre-feet from urban efficiency.)

Improved Water Agency Integration: The principles of integrated regional water management planning should form the foundation for improving cooperation and integration among Bay Area, Central Valley, and Southern California water agencies to provide improved water supply reliability and quality benefits. Increasing integration and

² See attachment for additional detail regarding cost and yield estimates. Note that these are initial/capital costs, not annual per-acre-foot unit costs. A comprehensive BDCP analysis should also address operations and maintenance costs of a full range of alternative investments.

³ The Department of Water Resources Bulletin 160-2009

<http://www.waterplan.water.ca.gov/cwpu2009/index.cfm> (Volume 2, Chapter 2, page 2-13) states that agricultural water conservation costs range from \$35-\$900 per AF. Because of the width of this cost range, agricultural conservation is not included in the conceptual cost and yield numbers above. A final BDCP portfolio proposal should, however, include agricultural water use efficiency investments.

cooperation among these agencies could produce substantial potential benefits and cost-savings. For example, more than a dozen significant water agencies serve the Bay Area. Improved physical connections and increased cooperation among these agencies could reduce risks related to earthquakes and localized drought conditions, facilitate wastewater recycling, and utilize existing infrastructure more efficiently.

In Southern California, additional benefits could be obtained, for example, by facilitating water management agreements and programs among agencies with the potential to construct water recycling facilities and agencies that have groundwater storage resources. The Metropolitan Water District could operate its system to facilitate innovative and cost-effective water management programs between agencies in Southern California and elsewhere in the state. Southern California groundwater agencies could allow water from Southern California surface storage facilities to be managed conjunctively with regional groundwater storage facilities. This could, in essence, create new surface storage capacity at the far lower cost associated with groundwater storage. This approach could help take advantage of the supplies available during “big gulp” opportunities in the Delta. Similar potential benefits may exist through increased integration and cooperation in the agricultural sector.

In all of these opportunities it is imperative that program costs be clearly identified and allocated to the water suppliers that benefit. In this way, each public water supplier is able to account to the public it serves that their water ratepayer dollars are being spent wisely, according to law and in a manner that provides clear benefits.

New South of Delta Surface and/or Groundwater Storage: Include up to 1 MAF⁴ of new South of Delta storage, with funding allocated through competitive bidding to evaluate proposed surface, groundwater and conjunctive use projects. Investments should be focused on projects that can be completed quickly and that are most cost-effective. Additional South of Delta storage⁵ can allow for greater water exports in wetter years. As discussed above, surface storage south of the Delta could be used conjunctively with groundwater facilities to store wet-year exports for future dry years. This increase in storage capacity must be accompanied by new Delta operations that ensure that the new storage will be operated to implement “big gulp, little sip” operations.

Levee Improvements: Improve existing levees and build setback levees as part of habitat restoration. A \$1 billion additional investment could improve Delta levees to protect life, property, and important infrastructure, and also upgrade key levees including the eight western Delta islands to a higher standard with improved stability and resilience

⁴ This 1 MAF storage target is based on limited BDCP modeling and may be revised based on further analysis.

⁵ As used in this proposal, South of Delta storage is defined as storage integrated into the existing SWP and CVP Delta export system, including surface and groundwater storage in the Bay Area, the west side of the San Joaquin Valley, Kern County and Southern California. It includes storage controlled by the CVP, the SWP, MWD, Kern County Water Agency and other regional and local agencies.

in the face of seismic risk. Upgrading these key levees would provide significant water reliability benefits and would be an appropriate use of exporter funds.

Regardless of the size of a Delta facility, maintaining and improving Delta levees is critical to ensuring the physical reliability of Delta exports. Even with new conveyance, the CVP and SWP will continue to rely on water exports from the South Delta, particularly in drier years. With a 9,000 cfs facility, exports from the South Delta would constitute approximately 50 percent of total exports. In critically dry years, BDCP currently anticipates that 75 percent of total exports would be diverted from the South Delta.⁶ Therefore, the benefits of this proposed investment in levee improvements would be particularly significant in dry years. BDCP does not currently include a strategy to reduce the physical vulnerability of the portion of Delta exports that would continue to rely on the Delta levee system.

East Bay Municipal Utility District, Contra Costa Water District and Delta landowners currently contribute to the maintenance of the levees upon which they rely. An analogous investment by export agencies would produce significant reliability benefits. For example, with average exports of 4 MAF/y, a contribution of \$8/AF would produce \$480 million to help improve Delta levees over the coming 15 years. Public funds for levee improvements are appropriate to protect Delta residents and infrastructure of regional and state importance (e.g. highways). Additional local contributions may be required.

Delta Floodplain and Tidal Marsh Habitat Restoration: Implement a large scale, approximately 40,000 acre habitat restoration program to benefit Delta fish and wildlife species, to provide a broad range of ecosystem functions and to be integrated with Delta flood management improvements. There is strong scientific evidence that floodplain habitat restoration, combined with adequate flows, can benefit salmon and other species. However, agency “red flag” memos and the National Research Council review of the existing biological opinions concluded that floodplain restoration cannot substitute for required ecosystem flows. Restoration of tidal marsh habitat, also a desirable activity, nonetheless, has far greater uncertainty associated with it, regarding benefits for many covered species, in comparison with the likely benefits of floodplain restoration. Tidal marsh restoration should be included in the BDCP plan as a complement to flow augmentation and floodplain restoration, as it is more likely to benefit some covered fish species in combination with these elements. Habitat restoration, particularly tidal marsh restoration, should in any case be implemented within an adaptive management framework. Existing CVP and SWP mitigation responsibilities, as well as new mitigation responsibilities associated with a new Delta facility, will be paid for by water exporters, while public funding should be focused on conservation benefits that go beyond

⁶ BDCP Draft Effects Analysis, April 13, 2012. Tables C.A-24 and C.A-27 from Appendix 5.C - Attachment C-A, which can be found on p. C.A. 83 and C.A. 92 at this link: <http://baydeltaconservationplan.com/Libraries/Dynamic Document Library/BDCP Effects Analysis - Appendix 5 C Attachment C A - CALSIM and DSM2 Results 4-13-12.sflb.ashx>

mitigation. This proposal is focused on the coming 15-20 years. Long-term restoration efforts are likely to require additional funding.

Integrating Science into Delta Management: Increase the integration of the best available science into all aspects of Delta and related resource management. The Delta is a complex and highly dynamic system. During the past decade, an expanded investment in science has improved our understanding of this ecosystem. With ongoing investments, that understanding will continue to improve. A long-term investment in science and a program to integrate new scientific results into ongoing management are essential to long-term success. Therefore, BDCP should include the following:

- External independent scientific review at critical points, with clear mechanisms to incorporate peer review results.
- Quantified performance objectives, such as SMART⁷ biological objectives and criteria for ecosystem restoration and water operations.
- Governance and adaptive management processes designed to ensure that goals and objectives are achieved, to obtain the best available science over time, and to ensure that scientific results are fully integrated into on-the-ground management.
- Carefully designed roles for the state and federal projects, as well as other stakeholders, to ensure a reliance on objective science.

This science-based approach is not anticipated to result in large increases in project costs. In fact, this approach would increase the cost-effectiveness of BDCP efforts, and should result in savings.

Affording, and Paying for the Portfolio-Based Conceptual Alternative

Our organizations strongly support an analytically-based beneficiary pays approach to BDCP financing. We believe that the analysis of this portfolio approach will assist BDCP in developing detailed cost allocations and in attracting additional funding partners. It will also help reduce pressure for public funds and ensure that such funds are spent effectively and appropriately.

Preliminary cost estimates indicate that this conceptual alternative is less expensive than the current preliminary preferred BDCP project. In addition, some of the investments in this portfolio alternative, such as levee and local water supply investments, are likely to be necessary even with a large Delta facility. Therefore, the actual cost difference between these two different approaches may be larger than indicated here.

This conceptual alternative is more financially viable than the preliminary preferred 9,000 cfs Delta facility project. That project, pegged at \$14 billion or more, is proposed to be paid for by water exporters. Proposed habitat restoration could cost up to an

⁷ SMART objectives are those that are specific, measurable, achievable, relevant to the goal and timebound.

additional \$4 billion, raising the total capital cost of the current approach to approximately \$18 billion. By reducing the size of the project to a 3,000 cfs, single-bore facility, many billions of dollars can be freed up to invest in more local supply development and the water exporter shares of the other conceptual alternative components.

The water code requires water users to pay for a new Delta facility.⁸ The public share of this conceptual alternative could be funded in part by a reduced water bond. The increased benefits and reduced cost of this approach can assist BDCP in attracting increased funding from beneficiaries, reducing the pressure on the water bond. We believe that the diversified portfolio approach in this conceptual alternative could assist in the effort to develop a broadly supported and effective new water bond.

Estimated Cost Summary

Conceptual Portfolio Component	Estimated Cost	Source of Funding
New 3,000 cfs North Delta Facility	~ \$5-\$7 billion ⁹	Export water agencies
Local Supply Development	\$5 billion	Local water agencies and cost share per state Integrated Regional Water Management Program (IRWMP)
Improved Water Agency Integration	TBD (may be funded through local supply funds described above)	Water agencies and cost share per state IRWMP
New South of Delta Surface and/or Groundwater Storage	~\$1.2 billion ¹⁰	Exporters or local water agencies, and public cost share per IRWMP
Levee Improvements	\$1 billion	Public, water exporters and other beneficiaries and Delta community
Delta Floodplain and Tidal Marsh Habitat Restoration	\$1.7 billion	Export agencies and public
Integrating Science into Delta Management	TBD	Public and water agencies
Total Conceptual Alternative Cost	~\$14 to \$16 billion	

⁸ California Water Code Section 85089.

⁹ A BDCP July 1, 2010 presentation estimated the capital cost of a 3,000 cfs facility with 2 18-foot diameter tunnels at \$7.2 billion. Using a single tunnel would reduce costs significantly.

¹⁰ See attachment for details regarding cost estimates.

Portfolio-Based BDCP Conceptual Alternative

January 16, 2013

P. 7

Total Conceptual Alternative Water Supply Benefits

~ 4.9-5.5 MAF/YR.

Delta exports: ~ 4-4.3 MAF/Y.

New South of Delta sources: ~ .93-1.2 MAF/Y

PHOTOGRAPH TASTE AND ODOR

Environmental Contaminant Treatment

Taste and Odor - Causing Compounds in Drinking Water

The primary sources of taste and odor problems in drinking water are algae and bacteria. However, other anthropogenic sources such as wastewater discharges and chemical spills also act as sources of chemicals that cause off tastes and odors. Such chemicals can affect both groundwater and surface water.

TYPES OF TASTE AND ODOR PROBLEMS

There are four basic taste types: sour, sweet, salty and bitter. There are also a variety of odor types including earthy, musty, chemical, and chlorinous. The table on the reverse side lists several taste and odor types and their potential causes.

THE CAUSES OF TASTE AND ODOR PROBLEMS

Some species of algae and bacteria naturally produce odorous chemicals inside their cells. **Geosmin** (trans-1, 10-dimethyl-trans-9-decalol) and **MIB** (2-methylisoborneol) are common odorous chemicals. The earthy and musty odors generated by geosmin and MIB are detectable by many people at concentrations of 5 to 10 parts per trillion. When large numbers of algae and bacteria flourish in a water body (an "algae bloom"), taste and odor-compound concentrations increase to levels above this threshold and cause taste and odor problems.

Cyanobacteria (Blue-Green Algae)

Cyanobacteria are known by several names, including "blue-green algae", "blue greens", and "cyanophyta". To the biologist, they are not technically algae (a multi-celled plant), but bacteria. This was not known until the advent of high-powered microscopes, however, the

common name "blue-green algae" has remained. Cyanobacteria are photosynthetic bacteria. In addition to the blue-green color of many inferred by the name, other species can be red, brown, or yellow. Cyanobacteria are most commonly found in eutrophic waters (waters with high levels of nutrients) and shallow reservoirs, and can occur as surface scum, benthic (bottom) mats, and on aquatic weeds (Hoehn, 2002). In the 1960's and 1970's, it was discovered that cyanobacteria produce geosmin and MIB as intracellular by-products. As a bloom progresses, bacteria die, releasing these odorous chemicals into the water.

Actinomycetes

Actinomycetes are spore-forming bacteria that grow as branching filaments in water. Closely related to cyanobacteria, they have simple cells. Actinomycetes also live in soil. In fact, it is the geosmin-producing soil variety that causes soil to smell "earthy." Other species produce antibiotics. Aquatic actinomycetes grow in aerobic mud, on decaying vegetation, and in the excrement of zebra mussels. The bacteria help to degrade cellulose and other plant parts, and for this reason thrive as a result of an algae bloom (Hoehn, 2002). Actinomycetes, like cyanobacteria, produce geosmin and MIB.

Other Algal and Natural Sources

Green algae blooms in a reservoir can produce a grassy or fishy odor. Golden-brown algae, particularly the species *Synura*, can produce a cucumber, melon, or fishy odor. Biological activity in surface waters can produce 2,4-heptadienal and decadienal, which have a fishy, rancid odor. In addition, dissolved metals such as zinc, manganese, copper, and iron can produce a metallic taste.

Man-Made Chemicals

Man-made chemicals are another source of taste and odor-causing chemicals in drinking water. For example, methyl tertiary butyl ether (MTBE), a gasoline additive persistent in groundwater and recreational surface waters, has an odor threshold as low as 5 parts per billion. Dissolved in water, it smells oily and like turpentine. Industrial phenols can create odor problems. Hydrocarbons and volatile organic compounds such as fuels and solvents produce oily, paint-like, and medicinal odors.

ALGAE AND BACTERIA BLOOM PATTERNS

A bloom occurs in a surface water body when light, temperature, and nutrient conditions are favorable for one type of algae or bacteria over another. This combination allows one organism to become dominant. It is an ecological imbalance often triggered by pollution. Nitrates, organic phosphorus and ammonia are discharged into the water body from water treatment plants or are carried in by watershed runoff (including runoff from pig and cattle feed lots and fertilizer from agricultural fields). The conditions favorable to blooms are seasonal. Spring and winter conditions favor golden brown algae and fishy, cucumber odors. Summer and fall conditions favor geosmin and MIB-producing bacteria and earthy and musty odors. Generally, the most common bloom month is September.

MEASUREMENT AND REGULATION OF TASTE AND ODOR QUALITY

There are several methods of taste and odor quality measurement and very few regulations.

FACTSHEET

The most frequently used measuring system is the Total Odor Number (TON), a method based on the persistence of an odor after dilution. Other methods include Flavor Profile Analysis and analytical measurement of chemical concentrations. Regulatory limits are few. The United States Environmental Protection Agency (USEPA) has issued a secondary maximum concentration limit (MCL) limiting the TON to 3. Iron, manganese, copper, and zinc have USEPA MCLs ranging from 0.5 to 5 parts per million. However, the primary regulator with respect to taste and odor is the consumer.

ALGAL TOXINS

In addition to producing chemicals that impact the aesthetic quality of water, certain species of cyanobacteria produce toxins ("cyanotoxins") that can cause harm to animals and humans. Toxic cyanobacteria are indistinguishable from non-toxic cyanobacteria under a microscope and both types may be present in a bloom. Multiple classes of cyanotoxins exist, including microcystin, cylindrospermopsin, and anatoxin-a. Cyanotoxins can be present wherever blooms occur and as a result, several regulating agencies worldwide have issued guidance regulations. Research in the U.S. and Canada has shown that a high percentage of raw water taken from water supplies undergoing a cyanobacteria bloom contained cyanotoxins, in addition to other taste and odor-causing chemicals (Carmichael, 2001). In the U.S., the USEPA has listed freshwater cyanobacteria and their toxins on the Contaminant Candidate List. In addition, New Zealand, Germany, and the World Health Organization (WHO) have established microcystin guidelines of 1.0 ppb, while Canada has established a 1.5 ppb guideline.

TREATMENT ALTERNATIVES – UV LIGHT A KEY

Many utilities use powdered activated carbon (PAC) to treat taste and odor problems. However, large doses of PAC are required to treat geosmin and MIB, making it impractical, especially for

TASTE OR ODOR	SOURCE
Earthy	Geosmin
Musty	MIB, isopropylmethoxypyrazine (IPMP), isobutylmethoxypyrazine (IBMP)
Turpentine-like	Methyl tertiary butyl ether (MTBE)
Fishy/finny	2,4-Hydroxybenzyl alcohol, 2,4-dichloro-2,4-dichlorobenzyl alcohol
Chlorinous	Chlorine
Medicinal	Chlorophenols, ketones
Oil, greasy, paint	Hydrocarbons, volatile organic compounds (VOCs)
Metallic	Iron, copper, zinc, manganese
Grassy	Green algae

larger utilities. Chlorine is widely used for the oxidation of taste and odor-causing chemicals, but itself can produce chlorinous odors and disinfection by-products such as THMs and HAAs. Ozonation is also used, but is expensive, complex to operate, and can form bromate, a harmful by-product. However, UV-photolysis and UV-oxidation using UV light and hydrogen peroxide is a cost-effective alternative for treating a wide variety of taste and odor problems. MIB, geosmin, MTBE, phenols, VOCs, and many others contaminants can be treated with UV-oxidation. This technology requires the photolysis of hydrogen peroxide with UV light to generate hydroxyl radicals. The hydroxyl radical is one of the most powerful oxidizing agents known and reacts rapidly with organic constituents in the water, including taste and odor compounds, breaking them down into their elemental, non-odorous components. Trojan's UV-oxidation reactors provide a reliable barrier to taste and odor compounds and do not form bromate. In addition, the same UV system used for taste and odor control simultaneously performs disinfection. This reduces or eliminates the source of unpleasant chlorinous odors resulting from the use of chlorine as a primary disinfectant.

TREATING MULTIPLE CONTAMINANTS WITH ONE UV SYSTEM

As a further benefit to taste and odor control and microbial disinfection, the Trojan UV system will disinfect *Cryptosporidium* and *Giardia*. The process will also treat many other dissolved organic compounds present in the water, including endocrine disruptors, *N*-nitrosodimethylamine (NDMA), pesticides, and algal toxins.

For over 30 years, Trojan has specialized in UV applications for water treatment and wastewater disinfection. Over 6,500 Trojan UV systems are treating municipal wastewater in more than 80 countries around the world. Tens of thousands of industrial and residential Trojan UV treatment systems are in operation in industries and households worldwide. Now, Trojan offers the industry standard in Environmental Contaminant Treatment (ECT). Trojan's UV-photolysis and UV-oxidation systems are capable of cost-effectively removing environmental contaminants from a variety of water streams. With its optimized technology, Trojan is the leader in ECT, offering the most cost-effective, highest quality UV solutions available.



References:

- Heaton, R. C. 2002. "Odor Production by Algae." Conference Workshop Presentation: Understanding and Controlling the Taste and Odor of Drinking Water. AWWA Annual Conference, New Orleans, June 16, 2002.
- Carmichael, W. W. 2001. Assessment of Blue Green Algal Toxins in Raw and Finished Drinking Water. AWWA Research Foundation, Denver, 179 pp.

North America: T. 519.457.3400 F. 519.457.3030 www.trojanuv.com
Europe (please contact our UK office): T. +44 (1905) 771117 F. +44 (1905) 772270

© Copyright 2010, Trojan Technologies, London, Ontario, Canada.
No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means without the written permission of Trojan Technologies. ECT-1110

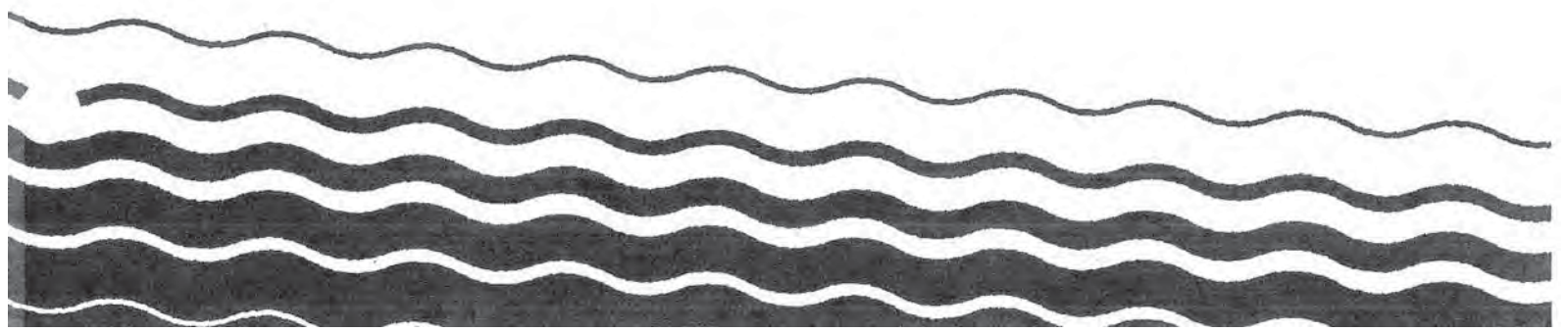
United States
Environmental Protection
Agency

Office of Water
(4601)

EPA 815-R-98-005
August 1998



Empirically Based Models for Predicting Chlorination and Ozonation By-Products: Trihalomethanes, Haloacetic Acids, Chloral Hydrate, and Bromate



EMPIRICALLY BASED MODELS FOR PREDICTING
CHLORINATION AND OZONATION BY-PRODUCTS:
TRIHALOMETHANES, HALOACETIC ACIDS, CHLORAL HYDRATE, AND BROMATE

By:

Gary Amy, Mohamed Siddiqui,
Kenan Ozekin, Hai Wei Zhu, and Charlene Wang
University of Colorado at Boulder

Number CX 819579

Project Officers:

James Westrick and Hiba Shukairy
Office of Ground Water and Drinking Water
U.S. Environmental Protection Agency
Cincinnati, Ohio

August 1998

The information in this document has been funded wholly or in part by the United States Environmental Protection Agency under Cooperative Agreement CX 819579 with the University of Colorado. It has been subjected to the Agency's peer and administrative review, and it has been approved for publication as an EPA document. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

FORWARD

This study was initiated to help the U.S. EPA, as a regulatory agency, and U.S. water utilities, impacted by EPA drinking water regulations, promulgate and meet new standards on disinfection by-products (DBPs). At the time of this report, new/revised regulations were being proposed for both chlorination and ozonation by-products. Most of the analytical and modeling work was performed over the 1994-1995 time frame.

This report documents a series of statistically-based empirical models for use in predicting disinfection by-products (DBPs) formed during water treatment disinfection using chlorine or ozone. The models were created and calibrated from a data base derived from bench-scale assessment of a diverse range of waters, including both surface water and groundwater sources. Each model was formulated through multiple step-wise regression analysis, and as such takes the form of a multiple regression equation. After formulation and calibration, model simulations were performed to compare predicted versus measured values, employing the same data base used in model calibration. Finally, each model was validated by using data derived from the literature. The relevant chlorination DBPs include haloacetic acids (HAAs), trihalomethanes (THMs), and chloral hydrate (CH). Bromate (BrO_3^-) served as the ozonation DBP of interest. For both chlorination and ozonation, dissolved organic carbon (DOC) has been used to represent the organic DBP precursor, while bromide ion (Br^-) represents the inorganic precursor. For the chlorination DBPs, model variables includes water quality conditions; DOC, Br^- , pH, and temperature; and treatment conditions represented by chlorine dose and reaction time. The models permit prediction of total HAAs (within the context of this report, total HAAs, THAA, corresponds to sum of six species, HAA_6), total THMs, and CH as a function of time; supplementary models permit estimates of each of the four THM species, and each of six HAA species. These models have been further adapted to apply to either raw/untreated waters or (alum or iron) coagulated waters where DBP precursor removal can be realized; of particular note is the ability of these models to account for coagulation induced changes in DBP reactivity. Bromate models permit predictions based on water quality conditions; DOC, Br^- , pH, and temperature; and treatment conditions reflected by transferred ozone dose and contact time. Supplementary models were developed to describe corresponding ozone decay as a function of time. All of these models presented herein are intended for use by both utilities and regulators. They can be used to assess the impact of changing water quality conditions on DBP formation, or to evaluate the impact of treatment modifications.

CONTENTS

Foreward.....	iii
Abstract.....	iv
Figures	vi
Tables	viii
List of Acronyms.....	ix
1. Introduction.....	1
Background.....	1
Research Objectives.....	2
Data Base and Models.....	2
Intended Model Users.....	3
2. Experimental Methods and Procedures.....	4
Analytical Methods.....	4
Analytical Quality Control.....	12
Bench-Scale Testing Methods.....	14
Statistical Methods.....	20
3. Source Waters and Data Base Summary.....	24
Raw/Untreated Waters.....	25
Coagulated Waters.....	28
4. Haloacetic Acid Models	33
Parameters Affecting Haloacetic Acid Formation.....	33
General Modeling Approach.....	37
Total Haloacetic Acids; Raw/Untreated Waters.....	38
HAA Species; Raw/Untreated Waters.....	44
Coagulated-Water Models.....	48
HAA Speciation Models; Br ⁻ /DOC as Master Variable.....	60
5. Trihalomethane Models.....	68
Individual Parameter Effects on TTHM and THM Species.....	69
Total Trihalomethanes; Raw/Untreated Waters.....	69
THM Species; Raw/Untreated Waters.....	73
Coagulated Waters.....	75
Effects of Bromide on THM Formation.....	86
Simulation and Validation of TTHM Predictive Models.....	89
6. Chloral Hydrate Models.....	97
Raw/Untreated Waters.....	97
Coagulated Waters.....	99
Surrogate Correlations between CH and TTHM or CHCl ₃	104
7. Chlorine Decay Models.....	109
Chlorine Residual Decay Models.....	109
DBP Formation versus Chlorine Exposure (C-T).....	114
8. Bromate and Ozone Decay Models.....	118
Parameters Affecting Bromate Formation.....	118
Comparison of Reactor Types.....	125
Modeling Efforts.....	125
Comparison of True-Batch with Semi-Batch Models.....	143
Evaluation of Control Options; Model Simulations.....	143
Organo-Br Formation.....	146
9. Model Applications.....	148
Chlorination By-Product and Chlorine Decay Models.....	148
Ozonation By-Product and Ozone Decay Models.....	149
References.....	150

2.1 Typical GC Chromatogram Showing HAA Species Peaks.....	5
2.2 Typical GC Chromatogram Showing THM Species and CH Peaks	6
2.3 Typical IC Chromatogram for Bromide Ion.....	8
2.4 Typical IC Chromatogram for Bromate Ion.....	9
2.5 Calibration Curve for Bromide Ion.....	10
2.6 Calibration Curve for Bromate Ion.....	11
3.1 Location of Utilities/Source Waters.....	26
3.2 Results of Alum Coagulation Screening Experiments.....	30
3.3 Results of Iron Coagulation Screening Experiments	31
4.1 Individual Parameter Effects on THAA Formation: Effects of Chlorine, pH, Temperature, Bromide, DOC, and Reaction Time.....	34
4.2 Individual Parameter Effects on HAA Species Formation: Effects of Chlorine, pH, Temperature, Bromide, and Reaction Time.....	35
4.3 Predicted versus Measured Values for Raw/Untreated Water THAAs; Weight-Based (ug/L) Model.....	41
4.4 Predicted versus Measured Values for Raw/Untreated Water THAAs; Identification of Individual Sources.....	42
4.5 Predicted versus Measured Values for Raw/Untreated Water THAAs; Molar-Based (umoles/L) Model.....	43
4.6 Overall External Validation using JMM Data with Raw-Water Model.....	45
4.7 External Evaluation of Kinetics using JMM Data with Raw-Water Model....	46
4.8 Predicted versus Measured Values for Raw-Water TCAA, DCAA, and BCAA....	47
4.9 Summation of Predicted Individual HAA Species vs Predicted Raw-Water THAAs; Weight-Based Models (ug/L).....	49
4.10 Predicted versus Measured Values of THAA for Coagulated/Treated Waters Using Combined Alum plus Iron Treated-Water Models.....	54
4.11 Predicted versus Measured Values of TCAA, DCAA, and BCAA for Coagulated/Treated Waters.....	55
4.12 Predicted versus Measured Values of THAA for Coagulated/Treated Waters Using Raw/Untreated Water-Models Combined with ϕ Concept; 24-Hour Predictions.....	57
4.13 Predicted versus Measured Values of THAA for Coagulated/Treated Waters Using Raw/Untreated Water-Models Combined with ϕ Concept; 96-Hour Predictions.....	58
4.14 Comparison of Predictions from Treated-Water Models versus Raw/Untreated Water Models Combined with ϕ Concepts.....	59
4.15 External Validation for Coagulated Water Model using JMM Data.....	61
4.16 Simulated Effects of Coagulation on THAA Formation	62
4.17 Fractional-Concentration Speciation Models; 24-Hour Predictions.....	63
4.18 Fractional-Concentration Speciation Models; 96-Hour Predictions.....	64
5.1 Individual Parameter Effects on TTHM Formation in HMR and VRW Sources..	70
5.2 Individual Parameter Effects on THM Species Formation in VRW Source....	71
5.3 Predicted versus Measured Values for Raw/Untreated Water TTHMs; Weight-Based (ug/L) Model.....	74
5.4 Summation of Predicted THM Species vs Predicted Raw-Water TTHMs; Weight-Based Models (ug/L).....	76
5.5 Predicted versus Measured Values of TTHM for Coagulated/Treated Waters Using Combined Alum plus Iron Treated-Water Models.....	81
5.6 Predicted versus Measured Values of TTHM for Coagulated/Treated Waters Using Combined Alum plus Iron Treated-Water Models; Individual Sources.....	82
5.7 Predicted versus Measured Values of TTHM for Coagulated/Treated Waters Using Raw/Untreated Water-Models with ϕ Concept.....	84
5.8 Comparison of Predictions from Treated-Water Models versus Raw/Untreated Water Models with ϕ Concept.....	85
5.9 Fractional-Concentration Speciation Models; 24-Hour Predictions.....	90
5.10 Fractional-Concentration Speciation Models; 96-Hour Predictions.....	91
5.11 Overall External Validation using JMM Data with Raw-Water TTHM Model..	92
5.12 External Validation of Kinetics using JMM Data with Raw-Water TTHM Model.....	94

5.13 Simulated Effects of Coagulation on TTHM Formation.....	95
5.14 External Validation of Alum Treated-Water Model and Combined Alum plus Iron Treated-Water Model using JMM Data.....	96
6.1 Individual Parameters Effects on CH Formation: Effects of Chlorine, pH, Temperature, Bromide, DOC, and Reaction Time.....	98
6.2 Predicted versus Measured Values for Raw/Untreated Water CH.....	101
6.3 Predicted versus Measured Values of CH for Coagulated/Treated Waters Using Combined Alum plus Iron Treated-Water Models.....	103
6.4 Predicted versus Measured Values of CH for Coagulated/Treated Waters Using Raw/Untreated Water-Models Combined with ϕ Concept; 24-Hour Predictions.....	106
6.5 Simulated Effects of Coagulation on CH Formation.....	107
6.6 Correlations Between CH and Chloroform (top) or TTHMs (bottom).....	108
7.1 Predicted versus Observed Chlorine Decay.....	113
7.2 THHA as a Function of Chlorine Exposure (C-T) for Raw/Untreated (top) or Treated (bottom) Waters.....	115
7.3 TTHM as a Function of Chlorine Exposure (C-T) for Raw/Untreated (top) or Treated (bottom) Waters.....	116
7.4 CH as a Function of Chlorine Exposure (C-T) for Raw/Untreated (top) or Treated (bottom) Waters.....	117
8.1 Individual Parameter Effects on Bromate Formation; Effects of pH, Ozone Dose, Bromide Concentration, pH Depression/Ammonia Addition, and DOC.....	120
8.2 Effect of Dissolved Ozone on Bromate Formation.....	121
8.3 Effect of Reactor Type on Bromate Formation	126
8.4 Predicted versus Measured Dissolved Ozone Using Semi-Batch, True Batch-EPA, and True Batch-EPA+EBMUD Models.....	130
8.5 Predicted versus Measured Bromate Using Semi-Batch, True Batch-EPA, and True Batch-EPA+EBMUD Models.....	132
8.6 Predicted versus Measured Bromate Using Semi-Batch, True Batch-EPA, and True Batch-EPA+EBMUD Models; without Ammonia.....	133
8.7 Predicted versus Measured CT (Exposure Time) Using True Batch-EPA and True Batch-EPA+EBMUD Models.....	136
8.8 Predicted versus Measured Bromate Using True Batch-EPA and True Batch-EPA+EBMUD CT (Exposure Time) Models.....	138
8.9 Bromate Formation as a Function of Ozone Exposure (CT); Variable Bromide.....	139
8.10 Bromate Formation as a Function of Ozone Exposure (CT); Constant Bromide.....	140
8.11 External Validation of Models with Literature Data (Data from Table 8.5).....	142
8.12 Predicted Bromate Using True Batch-EPA Model versus Semi-Batch Model..	144
8.13 Bromate Control Options; Simulations of True Batch-EPA Model.....	145
8.14 Individual Parameter Effects on Bromoform Formation (Semi-Batch); Effects of pH, Ozone Dose, Bromide Concentration.....	147

2.1	Minimum Reporting Levels.....	13
2.2	Coefficients of Variation (C.V.) for HAA Species	15
2.3	Coefficients of Variation (C.V.) for THM Species and CH.....	16
2.4	Coefficients of Variation (C.V.) for BrO_3^- and DO_3	17
2.5	Performance Evaluation of EPA Samples.....	18
3.1	Source Water Characteristics: Raw/Untreated.....	27
3.2	Source Water Characteristics: After Coagulation	32
4.1	Predictive Raw-Water Models for Haloacetic Acids (HAA):	
	Total HAAs (THAA) HAA Species.....	39
4.2	Predictive Coagulated-Water Models for THAA and HAA Species:	
	Alum Models.....	50
4.3	Predictive Coagulated-Water Models for THAA and HAA Species:	
	Iron Models.....	51
4.4	Predictive Coagulated-Water Models for THAA and HAA Species;	
	Combined Alum plus Iron Models.....	52
4.5	Summary of Reactivity Coefficient, ϕ , Values for THAAs.....	56
4.6	Summary of Fractional-Concentration HAA Speciation Models;	
	24-Hour Predictions.....	65
4.7	Summary of Fractional-Concentration HAA Speciation Models;	
	96-Hour Predictions.....	66
5.1	Predictive Raw-Water Models for Trihalomethanes (THM):	
	Total THMs (TTHM) and THM Species.....	72
5.2	Predictive Coagulated-Water Models for TTHM and THM Species:	
	Alum Models.....	77
5.3	Predictive Coagulated-Water Models for TTHM and THM Species:	
	Iron Models.....	78
5.4	Predictive Coagulated-Water Models for TTHM and THM Species;	
	Combined Alum plus Iron Models.....	80
5.5	Summary of Reactivity Coefficient, ϕ , Values for TTHMs	83
5.6	Summary of Fractional-Concentration THM Speciation Models;	
	24-Hour Predictions.....	87
5.7	Summary of Fractional-Concentration THM Speciation Models;	
	96-Hour Predictions.....	88
6.1	Predictive Raw-Water Models for Chloral Hydrate (CH).....	100
6.2	Predictive Coagulated-Water Models for Chloral Hydrate (CH);	
	Alum, Iron, and Combined Alum plus Iron Models	102
6.3	Summary of Reactivity Coefficient, ϕ , Values for CH	105
7.1	Reaction Rate Constants of Chlorine Decay.....	111
8.1	Predictive Models for Ozone Decay.....	128
8.2	Predictive Models for Bromate Formation.....	131
8.3	Predictive Models for CT, Exposure Time.....	135
8.4	Predictive Models for Bromate Formation with CT	137
8.5	External Validation of Models with Literature Data	141

LIST OF ACRONYMS

BCAA	Bromochloroacetic Acid
Br ⁻	Bromide (Ion)
BrO ₃ ⁻	Bromate
CH	Chloral Hydrate
CHBr ₃	Bromoform
CHBrCl ₂	Bromodichloromethane
CHBr ₂ Cl	Dibromochloroacetic Acid
CHCl ₃	Chloroform
Cl ₂	Chlorine
DBAA	Dibromoacetic Acid
DBPs	Disinfection By-Products
DCAA	Dichloroacetic Acid
D/DBP	Disinfectants/ Disinfection By-Products (Rule)
DOC	Dissolved Organic Carbon
F	F-Statistic
HAA _s	Haloacetic Acids
HAA ₆	Sum of TCAA + DCAA + MCAA + DBAA + MBAA + BCAA
HAA ₅	Sum of TCAA + DCAA + MCAA + DBAA + MBAA
MBAA	Monobromoacetic Acid
MCAA	Monochloroacetic Acid
MCLs	Maximum Contaminant Levels
O ₃	Ozone
r	Simple Correlation Coefficient
R	Multiple Correlation Coefficient
SEE	Standards Error of Estimate
SSE	Sum Squares Error
TCAA	Trichloroacetic Acid
THAA	Total HAA _s (corresponding to HAA ₆ in this report)
THMs	Trihalomethanes
TOC	Total Organic Carbon
TTHM	Total THMs
UVA	UV Absorbance (@ 254 nm)
α	Significance
φ	Reactivity Coefficient

SECTION 8

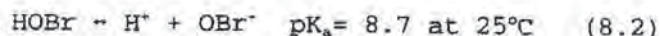
BROMATE AND OZONE DECAY MODELS

During the oxidation of natural waters containing bromide ion (Br^-) with ozone (O_3), bromate is formed at concentrations ranging from 0-150 ug/L under normal water treatment conditions. Bromide itself occurs ubiquitously, with an average concentration in the U.S. of almost 100 ug/L (Amy et al., 1994). Current studies show that bromate is a carcinogen. The Environmental Protection Agency (EPA) is currently considering a Maximum Contaminant Level (MCL) of 10 ug/L in U.S. drinking waters. Considering that the average bromide ion concentration in U.S. waters is 100 ug/L, it is expected that detectable bromate will form in a majority of waters which are subjected to ozonation. Therefore, an understanding of bromate formation during ozonation and the quantitative effects of water quality parameters (pH, alkalinity, DOC, etc.) is crucial for evaluating various bromate control strategies.

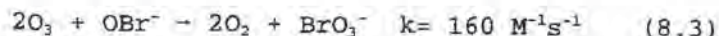
Haag and Hoigne (1983) suggest that bromide can be oxidized, by ozone, according to the following reaction:



The above reaction is pH dependent because hypobromite ion (OBr^-) is in equilibrium with hypobromous acid (HOBr) according to the following reaction:



Hypobromite ion can further react with ozone to form bromate;



The formation of bromate during ozonation can be influenced by water quality parameters (pH, DOC, Br^- , temperature) and various operational/treatment conditions (O_3 dose, dissolved O_3 residual, contact time).

PARAMETERS AFFECTING BROMATE FORMATION

An assessment of water quality characteristics (e.g. Br^- , pH, DOC) can help determine if a bromate problem is likely to occur. An understanding of treatment options can help reduce bromate formation. The effects of each parameter on bromate formation and ozone demand are discussed below.

Effect of pH

The effects of pH on bromate formation and ozone decay have been analyzed for each water source, and it was found that bromate concentration increases upon an increase of pH from 6.5 to 8.5, a trend largely attributable to the high OBr^-/HOBr ratio at higher pH levels. pH has been controlled in our experiments with a 10^{-3} M phosphate buffer; pH was monitored during experiments to assure that pH was constant within ± 0.1 units.

On the other hand, ozone decays faster in high pH waters than low pH waters. This is consistent with what other researchers have found (Weis, 1935; Hoigne and Bader, 1977; Staehelin et al., 1984; Tomiyasu et al., 1985; Grasso, 1987; Gordon, 1987). This behavior is attributed to direct reaction of hydroxide ions with ozone:

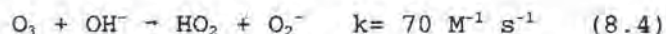


Figure 8.1a shows the effects of pH on bromate formation for SPW; increasing pH from 6.5 to 8.5 almost doubled the bromate concentration.

Effect of Ozone Dose

For low DOC waters ($\text{DOC} \leq 2.0 \text{ mg/L}$), an $\text{O}_3/\text{DOC} = 2 \text{ mg/mg}$ was selected as the baseline condition; however for the higher DOC waters ($\text{DOC} > 2 \text{ mg/L}$), an $\text{O}_3/\text{DOC} = 1 \text{ mg/mg}$ was selected in order to provide realistic ozone doses.

Bromate concentration was observed to increase with an increase in O_3/DOC ratio (Figure 8.1b). This is due to the direct reaction of ozone with OBr^- to form BrO_3^- . Bromate does not form after the ozone residual becomes zero (Figure 8.2). This is an important finding because this suggests that bromate primarily forms in treatment plants whereas most of the organic DBPs (e.g., bromoform) form within distribution systems after several hours of reaction time. This is also potentially advantageous because bromate can potentially be removed before treated water leaves the treatment plant.

In the case of high O_3/DOC ratios with low DOC waters, bromate formation steadily increases with time whereas ozone decays very slowly until all bromide is converted into bromate.

Effect of Bromide Concentration

Bromate formation and ozone decay in natural waters have been studied at

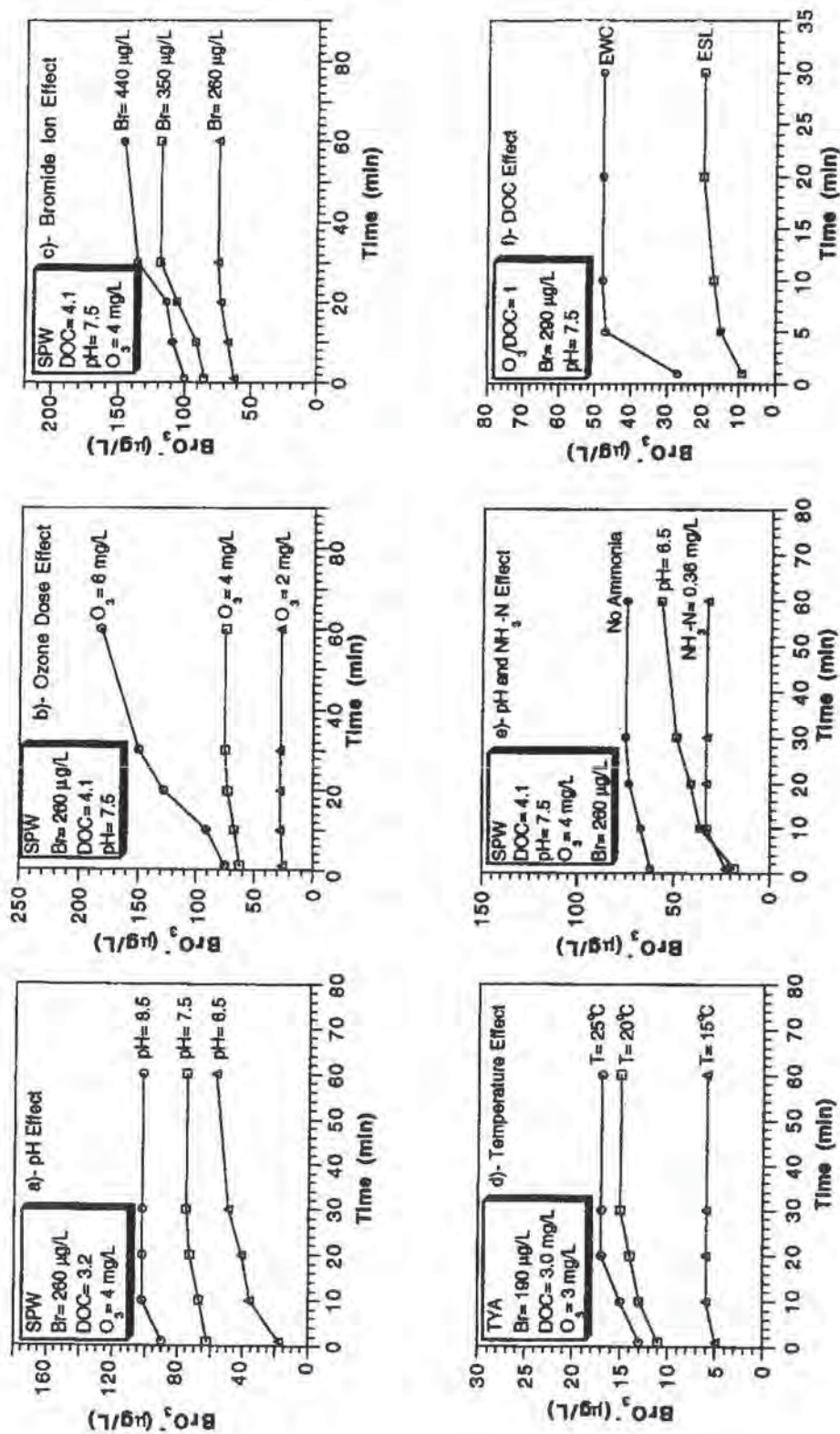


Figure 8.1. Individual Parameter Effects on Bromate Formation; Effects of pH, Ozone Dose, Bromide Ion Concentration, Temperature, pH Depression/Ammonia Addition, and DOC

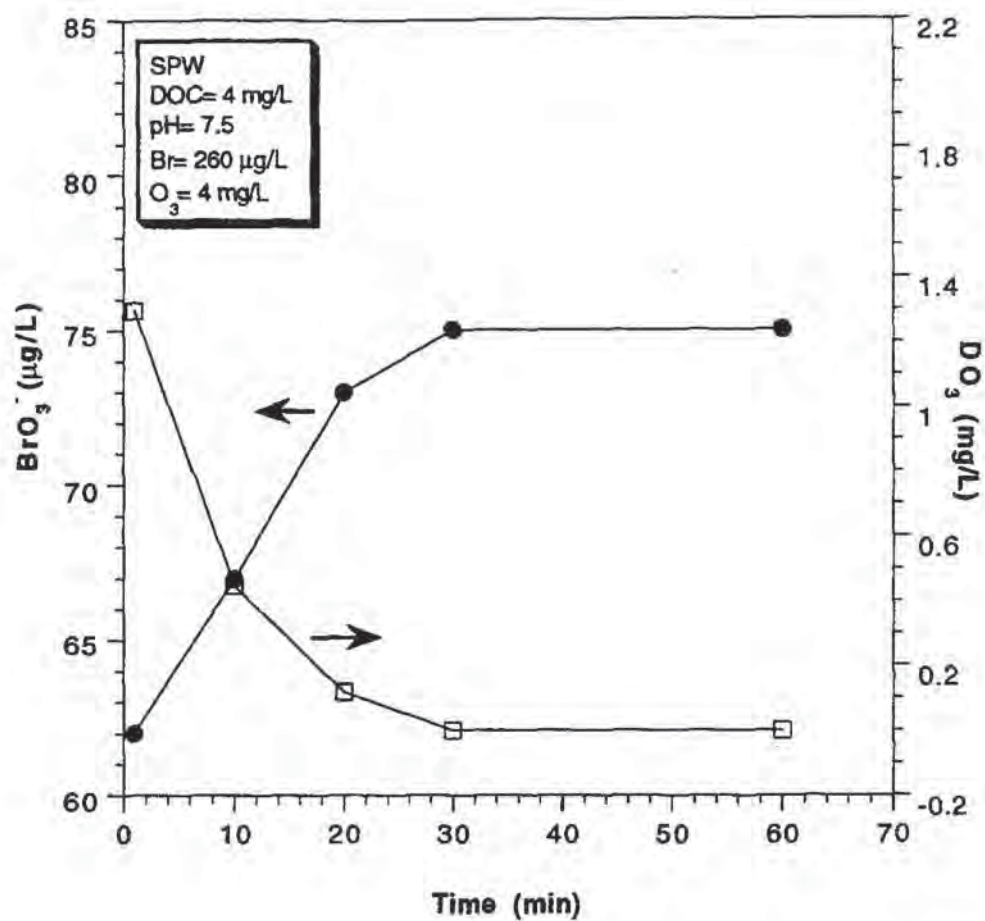


Figure 8.2. Effect of Dissolved Ozone on Bromate Formation

ambient Br^- , and at spiked levels of ambient + 0.1 mg/L (100 ug/L) and ambient + 0.2 mg/L (200 ug/L). In the case of high ambient Br^- levels ($\text{Br}^- > 80$ ug/L), ambient Br^- was chosen as the baseline condition, whereas for the low ambient Br^- levels, ambient + 0.1 mg/L was the baseline condition used in order to produce measurable quantities of bromate. A national survey indicates that Br^- levels in raw US drinking water supplies ranges from <0.005 mg/L to almost 0.5 mg/L with a national average of slightly less than 0.1 mg/L (Amy et al., 1994); therefore, the baseline conditions were maintained close to these levels.

Bromate concentration increased with increasing bromide ion concentration (Figure 8.1c), due to direct reaction of ozone with bromide to produce OBr^- which further reacts with ozone to produce bromate.

Siddiqui and Amy (1993) previously showed that BrO_3^- was not formed at bromide concentrations of less than 0.1 mg/L. However, in this study, it is clear that bromate formation is much more problematic than previously thought. Bromate forms (up to 6 ug/L) in waters containing bromide as low as 20 ug/L. This finding is important because bromate is a problem for significantly more water utilities than originally thought. The Siddiqui and Amy (1993) study was restricted by a much higher bromate detection limit than is currently possible. During the time of this study, the detection limit for bromate by IC has been lowered to 2 ug/L. The other difference between their study and this study is that they used a semi-batch mode of ozone application, whereas in this study a true batch mode of ozone application has been emphasized, and it has been found that bromate formation is reactor specific. Differences between two different modes of ozone application will be discussed later. Recent work by Amy et al. (1993) now suggests that there is no actual Br^- threshold level but only the analytical constraint of minimum detection limit (MDL); thus, any level of Br^- can form some BrO_3^- upon ozonation.

Effect of Temperature

From the Arrhenius relationship, the rate constant k of bromate formation can be considered temperature dependent in the following manner:

$$k = (a)e^{-E/RT} \quad (8.5)$$

where k = rate constant; T = absolute temperature; E = activation energy; R = universal gas constant; and a = constant.

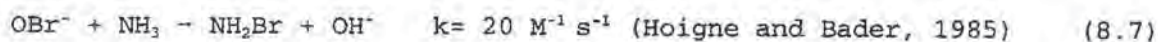
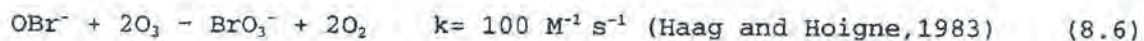
Thus, temperature is a potentially important water quality variable. The

effects of temperature on bromate formation were studied at 15, 20, and 25°C, with 20°C chosen as the baseline condition. The results show that bromate formation increases with increasing temperature (Figure 8.1d). This is generally consistent with what previous researchers have found. Siddiqui and Amy (1993) attribute this to a combination of the temperature-dependent increase in rate constants and a decrease in the pK_a of $\text{HOBr}-\text{OBr}^-$ with an increase in temperature.

Temperature also has a direct effect on ozone decay; an increase in temperature brings about a decrease in the dissolved ozone concentration (Roth and Sullivan, 1981; Hewes, C. et al., 1971; Sotelo, J.L. et al., 1989). This occurs due to a drop in the liquid phase driving force and to a higher ozone decomposition rate. Our results agree with the literature, and a higher ozone decomposition was observed with high temperature values.

Effect of Ammonia

The effect of ammonia on the formation of bromate and ozone decay was studied. NH_3/O_3 ratios of 0.2, 0.35, and 0.5 mg/mg were used in the experiments; the $\text{NH}_3/\text{O}_3 = 0.35$ mg/mg ratio corresponds to the stoichiometric conversion of Br^- to OBr^- and stoichiometric conversion of OBr^- to monobromamine (i.e., 1 mol of O_3 produces 1 mol of OBr^- which reacts with 1 mol of NH_3 to produce monobromamine, and thus the stoichiometric ratio of NH_3/O_3 can be calculated as; $\text{NH}_3/\text{O}_3 = (1\text{mol})/(1\text{mol}) = (17\text{g})/(48\text{g}) = 0.35$ mg/mg). It has been observed that addition of ammonia decreases bromate formation (Figure 8.1e). This is likely due to direct reaction of OBr^- with ammonia to form monobromamine or reaction of HOBr with ammonia and a corresponding conversion of OBr^- to HOBr . Adding excess ammonia ($\text{NH}_3/\text{O}_3 = 0.5$ vs 0.35 mg/mg) did not decrease the bromate formation further. This may possibly be attributable to the reaction competition between OBr^- and O_3 versus OBr^- and NH_3 :



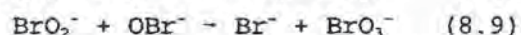
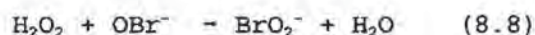
Effect of DOC

DOC exerts a very clear negative influence on bromate formation (Figure 8.1f). This effect is largely in response to its positive influence on ozone decay; i.e., DOC-related ozone demand. However, this effect is very source

specific with DOC from more humic sources generally exerting a greater ozone demand.

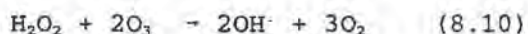
Effect of Hydrogen Peroxide

Peroxide effects on the formation of bromate and ozone decay were studied. Our results have shown that addition of peroxide increases bromate formation in some waters and decreases it in other waters. Thus, more work should be performed to understand the mechanisms of the influence of peroxide on bromate formation. Hydrogen peroxide may potentially react with OBr^- to produce bromate:



Ozone reaction with hydroperoxide ion (HO_2^-) is very fast ($k = 5.5 \times 10^6 \text{ M}^{-1} \text{ s}^{-1}$); thus, the presence of hydrogen peroxide in water significantly affects ozone decay. The ozone decomposition rate increases with increasing pH values. Peroxide effects have been studied only at baseline pH values, and results show that ozone decomposition is faster in the peroxide containing waters.

Peroxide effects are also manifested by its role in promoting hydroxyl radical ($\text{OH}^\cdot$) formation in the presence of ozone (Hoigne and Bader, 1985), and by its independent role in reducing hypobromite to bromide (Haag and Hoigne, 1983):



The stoichiometric ratio for peroxide production of $\text{OH}^\cdot$ radicals is $\text{H}_2\text{O}_2/\text{O}_3 = 0.35 \text{ mg/mg}$. Above this ratio, there is an excess of peroxide in the system.

Effect of Reaction Time

Reaction time is another parameter which affects bromate formation and ozone decay. Results show that bromate formation is directly related to the dissolved ozone concentration in water, and bromate does not form after dissolved ozone concentration goes to zero. In a majority of the water sources studied, ozone concentration decreased to zero in less than an hour (Figure 8.2), with an ozone half-life ranging from approximately 10 seconds to 30 minutes. Thus, bromate formation does not occur beyond a time frame of about one hour. Ozone reaction with bromide is fast, and most of the bromate formation occurs in the first five minutes after ozone application.

COMPARISON OF REACTOR TYPES

In work performed herein, two different reactor configurations have been employed: (i) semi-batch and (ii) true-batch. In the semi-batch ozonation system, ozone is applied continuously (mg/L-min) to a batch of water (L) for a predetermined application time (min) to achieve a targeted applied dose (mg/L); corresponding measurement of transfer efficiency (typically = 35% to 65%) allows determination of transferred/utilized ozone dose. In the true-batch approach, a stock solution of ozone ($\approx 35\text{--}40 \text{ mg/l}$) is prepared by exhaustive ozonation of Milli-Q water at $2\text{--}3^\circ\text{C}$ and then added to a batch of the source water of interest, and a teflon disk cover is used to prevent any transfer of ozone from the liquid phase to the gas phase.

Since dissolved ozone is directly responsible for bromate formation, the dissolved ozone profile at any time in the reactor is very important. In the semi-batch approach, dissolved ozone concentration increases with time during application (with a possible lag while most ozone demand is being met) and thereafter decreases with time after ozone application has ceased. Bromate also forms in response to the dissolved ozone present in water at any time during the application of ozone. In contrast, in the true batch approach, at time zero (the time of stock introduction), an initial system exists within which the reactants are at their maximum and the products do not exist; after time zero, ozone decays and bromate forms over time. Figure 8.3 shows bromate formation and ozone decay for semi batch and true batch modes of applications. Both reactor configurations have some advantages and disadvantages. The semi-batch mode is physically more similar to pilot-scale or full-scale continuous-flow ozone contactors than true-batch in terms of the continuous introduction of gas. In these systems (semi-batch or continuous-flow), it is necessary to measure transfer efficiency in order to determine utilized ozone dose. On the other hand, transfer efficiency is not a concern in the true-batch system, because applied and transferred ozone are identical. In the semi-batch application, one should always be concerned about head space in the reactor and any possible transfer of ozone from the liquid to gas phase. The biggest concern with the true batch approach can be associated with the dilution effect caused by adding a small amount of ozone stock solution to an aliquot of source water; however, dilution effects can be accounted for by redefining the original water characteristics.

MODELING EFFORTS

The experimental methods used in this study along with statistical approaches are explained in Chapter 2. Three type of models that are discussed

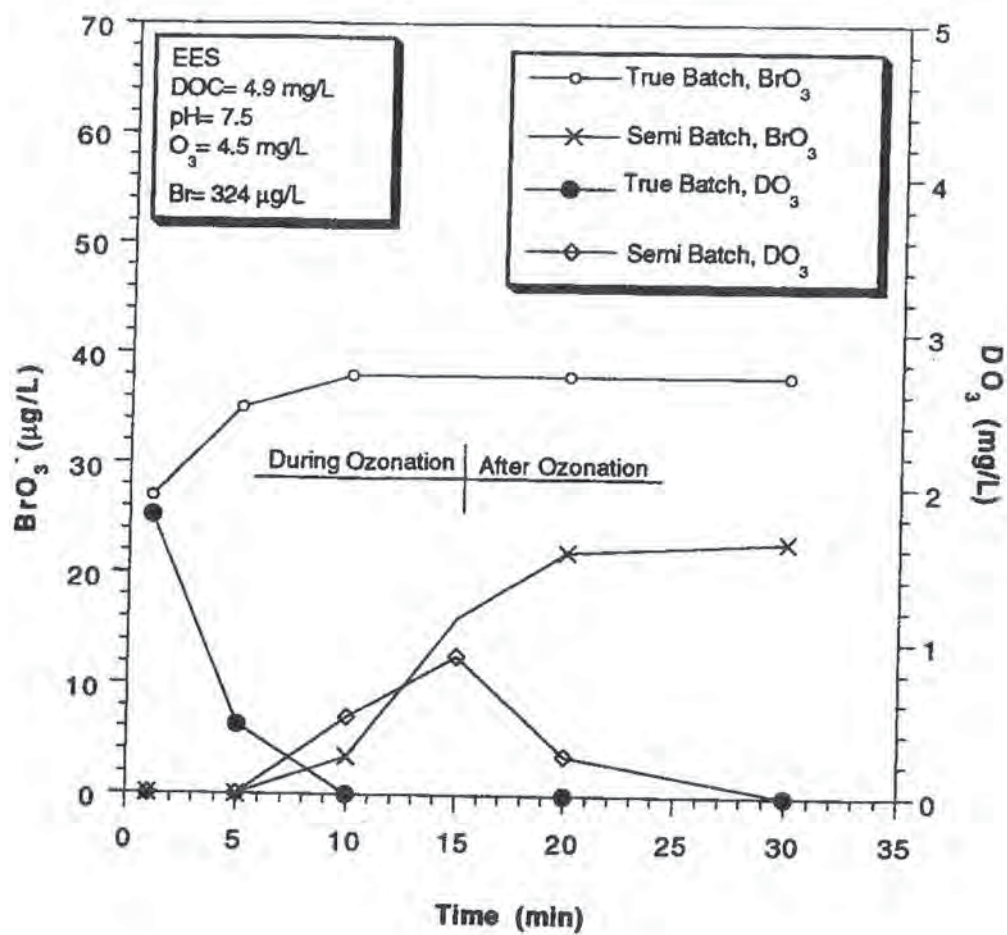


Figure 8.3. Effect of Reactor Type on Bromate Formation

herein were developed (i) semi-batch, (ii) true-batch-EPA, (iii) true-batch-EPA+EBMUD models. Semi-batch models were developed during the beginning stages of the project with data derived from semi-batch ozonation of the first five source waters selected as part of the EPA data base (n=113). True-batch models were developed during later stages with data derived from true-batch ozonation, consisting of two data bases; the EPA data base alone (n= 116) or the combined EPA+EBMUD data base (n= 176). The two true-batch models are similar in format except that the former was calibrated using data from a smaller yet diverse data base derived from six source waters; the latter was calibrated with a larger data base which was influenced by the four California waters comprising the EBMUD sources.

Step-wise multiple regression was used to develop the models according to a power function format; relevant statistical parameters include the number of cases (n) and the multiple coefficient of determination (R^2). Each model was tested through an internal validation, representing a data simulation with data used in model calibration. A perfect data simulation between predicted and measured values would be presented by a regression line with a slope of 1.0, an intercept of zero, and an r^2 of 1.0; this analysis also allows an assessment of model over- or under-prediction.

An important stipulation of the following models is the indicated boundary conditions, defined by the ranges over which each independent parameter was varied. These ranges were defined by the orthogonal matrix employed: $O_3/DOC = 0.5, 1.0^* 2.0$ mg/mg; $Br^- = amb., amb. + 0.1^*, amb. + 0.2$ mg/L; pH = 6.5, 7.5*, 8.5; $NH_3/O_3 = 0^*, 0.20, 0.35, 0.50$ mg/mg; temperature = 15, 20*, 25 C (* = baseline condition; for high ambient $Br^- > 80$ ug/L, amb. was used as the baseline; for low DOC waters ≤ 2.0 mg/L, $O_3/DOC = 2$ mg/mg was used as the baseline). The reaction times evaluated ranged from 1 to 60 minutes. For the semi-batch approach, ozone is applied at "absolute" time "zero" until some targeted dose is achieved; thereafter (post- O_3), the DO_3 residual is allowed to decay. The semi-batch models define reaction time (t) as beginning at the end of the application period, a "redefined" time zero.

Ozone Demand Models

Bromide directly reacts with ozone to form bromate, therefore an understanding of ozone decay and its relationship to bromate formation is crucial. Three different ozone decay models (semi-batch, true-batch-EPA, true-batch-EPA+EBMUD) are shown in Table 8.1. The model exponents shown in Table 8.1 demonstrate the ozone demand of DOC and the effect of pH on ozone decomposition. The coefficient associated with alkalinity demonstrates its stabilizing influence on O_3 decomposition. While temperature is not included

TABLE 8.1- PREDICTIVE MODELS FOR OZONE DECAY

a- Semi Batch Model**(Source Waters: BRW, SPW, BGW, MGW, HMR)**

$$[DO_3] = 182 (DOC)^{-2.66} (pH)^{-2.66} (O_3)^{1.52} (Br)^{0.176} (t+1)^{-0.53}$$

$$R^2 = 0.61, F = 34, N = 113, \alpha < 0.0001$$

b- True Batch Model; EPA Data Only**(Source Waters: BGW, PBW, ISW, SPW, TYA, HMR)**

$$[DO_3] = 357 (DOC)^{-1.79} (pH)^{-3.66} (O_3)^{1.83} (Br)^{0.08} (t)^{-0.59} (Alk)^{0.227}$$

$$R^2 = 0.66, F = 65, N = 116, \alpha < 0.0001$$

c- True Batch Model; EPA+EBMUD Data**(Source Waters: BGW, PBW, ISW, SPW, TYA, HMR, EIS, ESL, EBC, EES)**

$$[DO_3] = 2831 (DOC)^{-1.942} (pH)^{-4.79} (O_3)^{1.81} (Br)^{0.163} (t)^{-0.678} (Alk)^{0.236}$$

$$R^2 = 0.68, F = 83, N = 176, \alpha < 0.0001$$

where

 Br^- = Bromide ($\mu\text{g/L}$) ; $70 \leq [Br^-] \leq 440$ DO_3 = Dissolved Ozone (mg/L) ; $0.05 \leq [DO_3] \leq 4.6$ t = Time (min) ; $1 \leq t \leq 120$ pH; $6.5 \leq \text{pH} \leq 8.5$ DOC= Dissolved Organic Carbon (mg/L) ; $1.1 \leq \text{DOC} \leq 8.4$ O_3 = Transferred/Utilized Ozone (mg/l) ; $1.1 \leq O_3 \leq 10$ Alk = Alkalinity (mg/l); $13 \leq \text{Alk} \leq 316$

as a parameter in the models, it exhibits a significant influence on O_3 decomposition (slower at lower temperature). In the semi-batch model, the reaction time (t) is based on post-ozonation (after O_3 application has ceased) conditions. However, some ozone demand is met during ozonation; hence, the use of the $(t + 1)$ term in the model permits calculation of the ozone residual after ozone application at $t = 0$. Data simulations, in the form of predicted versus measured comparisons, are shown in Figure 8.4. All of the models show some overpredictions at lower values with underpredictions observed at higher values; predictions are most accurate under conditions leading to medium levels. The ozone residual models have potential relevance in making C-T predictions, a point discussed later in more detail.

Bromate Formation Models

Table 8.2 shows bromate formation models for semi-batch, true-batch-EPA, and true-batch-EPA+EBMUD data bases. Data simulations for all models are shown in Figure 8.5. Again, the reaction time, t , is based on post-ozonation conditions in the semi-batch bromate model. However, bromate can form during ozonation; thus, use of the $(t + 1)$ term in the model permits time-zero (the instant when ozone application has ceased) predictions. The regression lines suggest some propensity towards overpredictions at lower values, and underprediction towards higher values for all the models, with best predictions provided under mid-level conditions. In all of the models, while reaction time is shown to exert a positive effect, bromate does not form after the ozone residual goes to zero. Therefore, the bromate prediction models may potentially be coupled with the corresponding ozone residual models shown in Table 8.1. Once again, temperature effects are not encompassed by the models; greater bromate is observed at higher temperature.

Bromate formation models without ammonia as a parameter are also shown for true-batch-EPA and true-batch-EPA+EBMUD data sets in Table 8.2. Those models provide flexibility to water utilities that do not measure ammonia as a water quality parameter, or that do not contemplate ammonia addition as a control option. Data simulations using these models are shown in Figure 8.6. Again, overprediction at lower values, and underprediction at higher values are observed.

CT Models

In the Surface Water Treatment Rule (SWTR), disinfection is addressed by EPA through the use of CT values (defined as the product of residual ozone concentration in mg/L and effective contact time in minutes). Therefore, having a CT-based model would be useful in helping to understand the

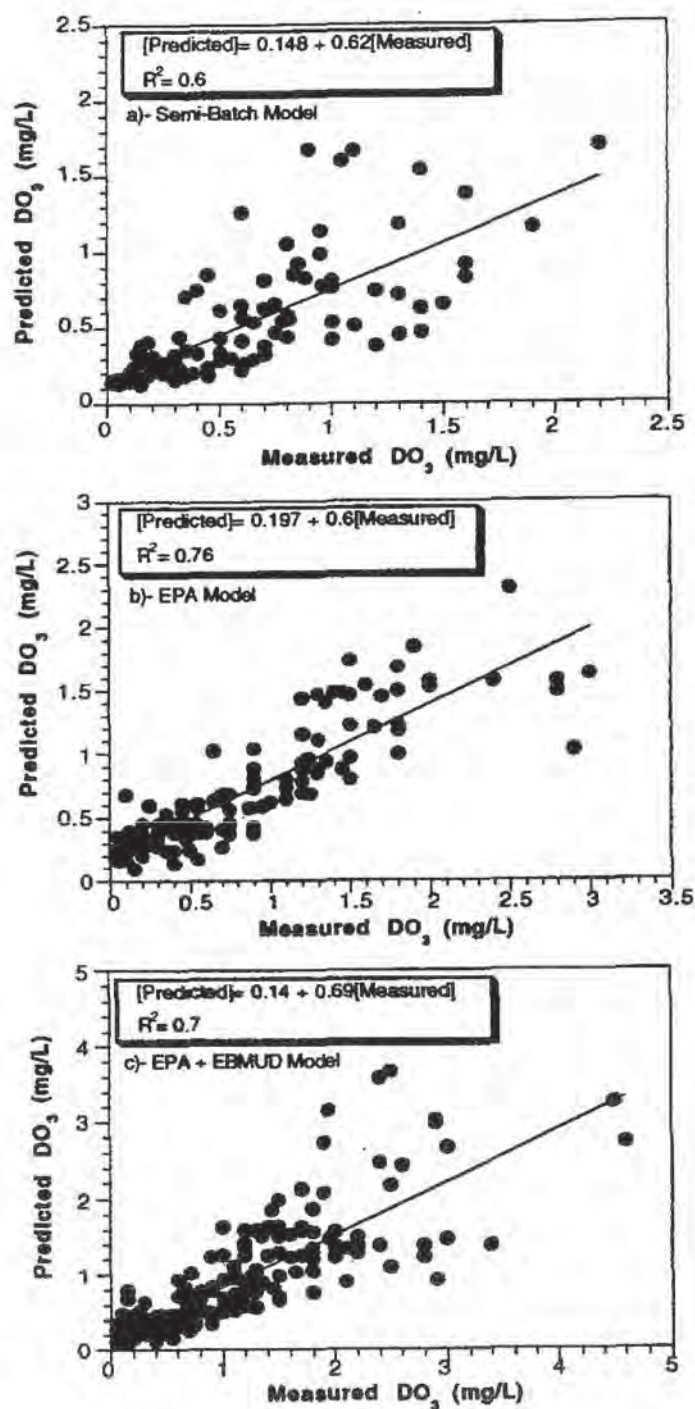


Figure 8.4. Predicted versus Measured Dissolved Ozone Using Semi Batch, True Batch-EPA, and True Batch EPA+EBMUD Models

TABLE 8.2- PREDICTIVE MODELS FOR BROMATE FORMATION

a- Semi Batch Model

(Source Waters: BRW, SPW, BGW, MGW, HMR)

$$[\text{BrO}_3] = 5.5 \times 10^{-6} (\text{DOC})^{-1.61} (\text{pH})^{4.54} (\text{O}_3)^{1.2} (\text{Br})^{1.06} (t+1)^{0.35}$$

$$R^2 = 0.62, F = 38, N = 113, \alpha < 0.0001$$

b- True Batch Model; EPA Data Only

(Source Waters: BGW, PBW, ISW, SPW, TYA, HMR)

1- without Ammonia

$$[\text{BrO}_3] = 2.74 \times 10^{-6} (\text{DOC})^{-1.32} (\text{pH})^{5.4} (\text{O}_3)^{1.36} (\text{Br})^{0.86} (t)^{0.31}$$

$$R^2 = 0.73, F = 61, N = 116, \alpha < 0.0001$$

2- with Ammonia

$$[\text{BrO}_3] = 1.1 \times 10^{-6} (\text{DOC})^{-1.09} (\text{pH})^{5.71} (\text{O}_3)^{1.16} (\text{Br})^{0.834} (t)^{0.29} (\text{NH}_3\text{-N})^{-0.31}$$

$$R^2 = 0.78, F = 83, N = 135, \alpha < 0.0001$$

c- True Batch Model; EPA+EBMUD Data

(Source Waters: BGW, PBW, ISW, SPW, TYA, HMR, EIS, ESL, EWC, EES)

1- without Ammonia

$$[\text{BrO}_3] = 4.3 \times 10^{-6} (\text{DOC})^{-1.44} (\text{pH})^{5.24} (\text{O}_3)^{1.58} (\text{Br})^{0.79} (t)^{0.292}$$

$$R^2 = 0.73, F = 103, N = 176, \alpha < 0.0001$$

2- with Ammonia

$$[\text{BrO}_3] = 2.32 \times 10^{-6} (\text{DOC})^{-1.47} (\text{pH})^{5.35} (\text{O}_3)^{1.65} (\text{Br})^{0.81} (t)^{0.28} (\text{NH}_3\text{-N})^{-0.121}$$

$$R^2 = 0.75, F = 106, N = 213, \alpha < 0.0001$$

where

 BrO_3^- = Bromate ($\mu\text{g/L}$) ; $2 \leq [\text{BrO}_3^-] \leq 314$ Br^- = Bromide ($\mu\text{g/L}$) ; $70 \leq [\text{Br}^-] \leq 440$ t = Time (min) ; $1 \leq t \leq 120$ pH ; $6.5 \leq \text{pH} \leq 8.5$ DOC = Dissolved Organic Carbon (mg/L) ; $1.1 \leq \text{DOC} \leq 8.4$ O_3 = Transferred/Utilized Ozone (mg/l) ; $1.1 \leq \text{O}_3 \leq 10$ $\text{NH}_3\text{-N}$ = Nitrogen ammonia (mg/l); $0.02 \leq \text{NH}_3\text{-N} \leq 3$

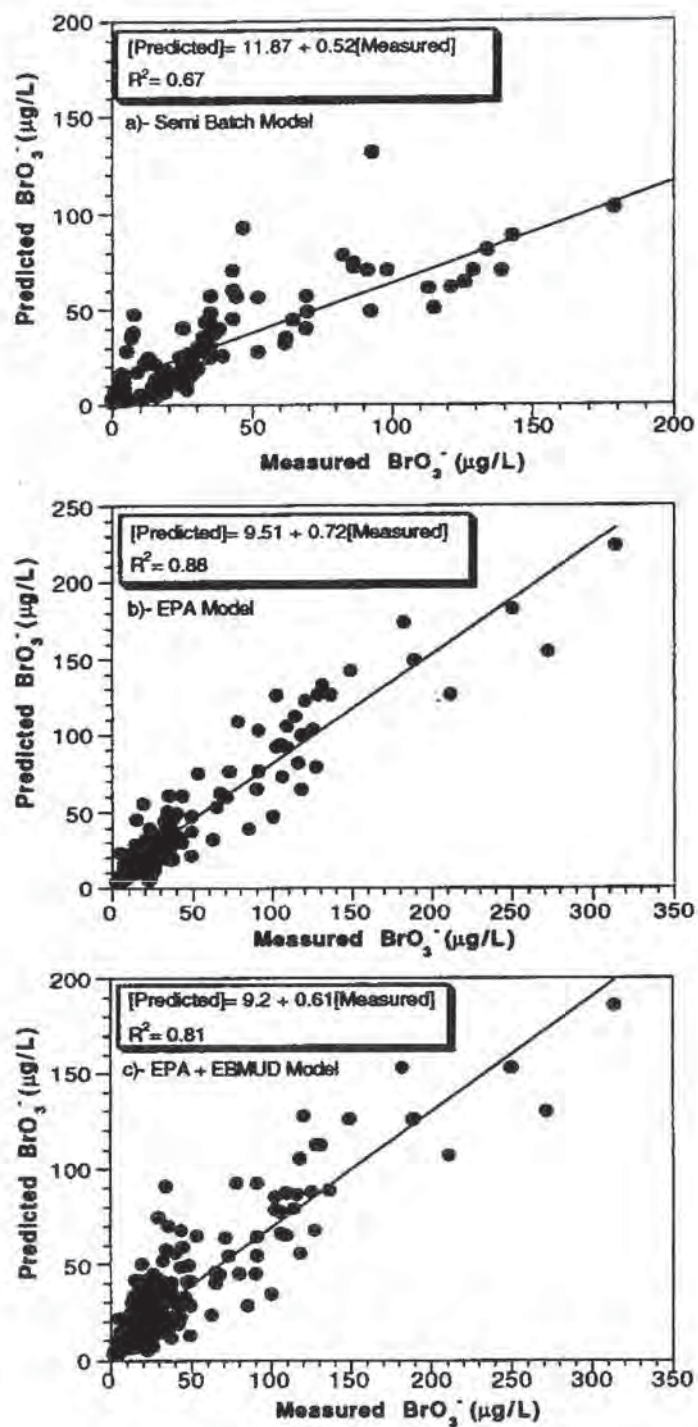


Figure 8.5. Predicted versus Measured Bromate Using Semi Batch, True Batch-EPA, and True Batch EPA+EBMUD Models

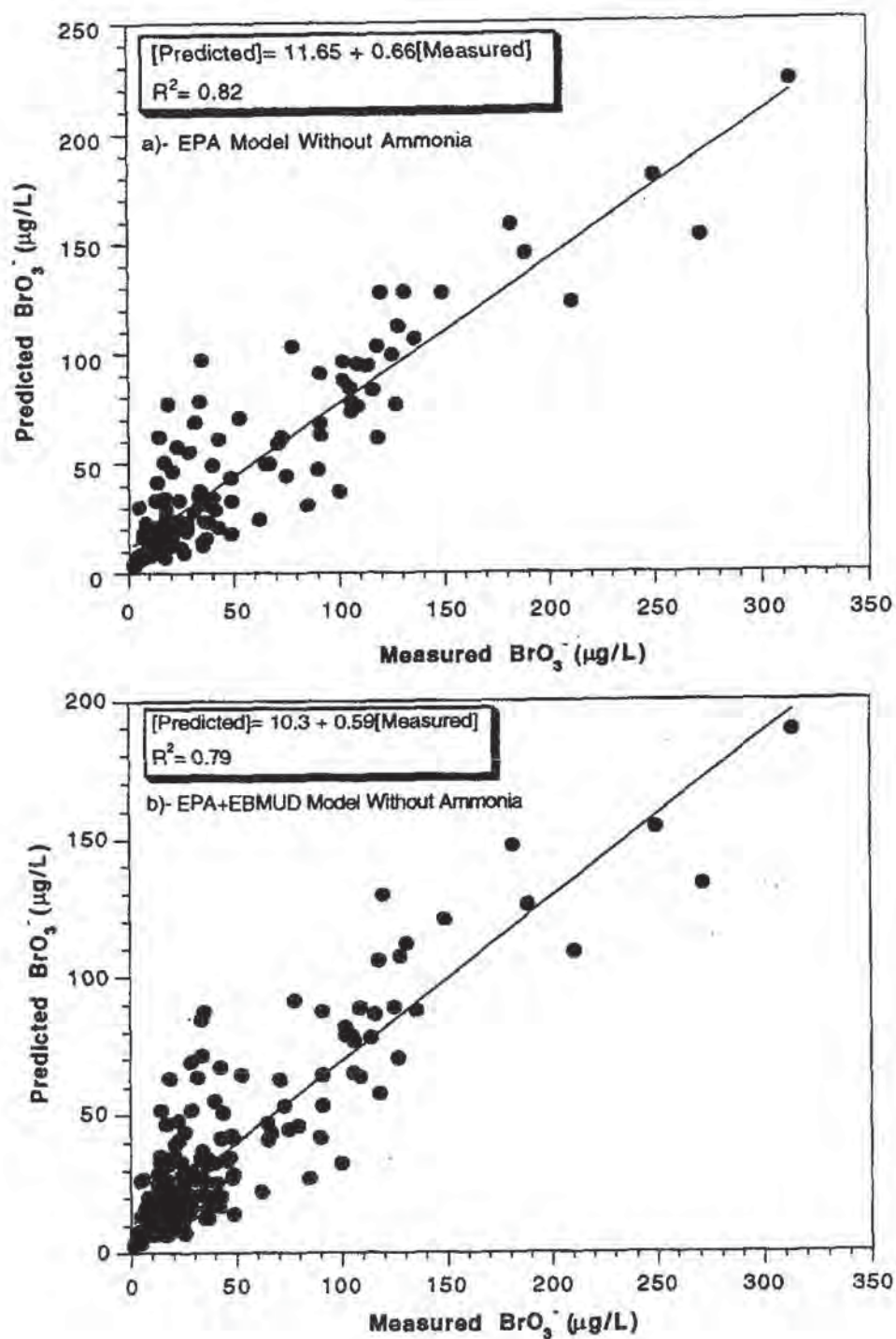


Figure 8.6. Predicted versus Measured Bromate Using True Batch-EPA, and True Batch EPA+EBMUD Models without Ammonia

relationship between DBPs and disinfection levels under certain water quality and operating conditions. The SWTR interpretation of CT involves the DO_3 residual (C) leaving a continuous-flow contactor and the t_{10} residence time (T). In a batch system, this parameter can be approximated by using the exposure time concept developed by Von Gunten and Hoigne (1993) which corresponds to integration of the ozone decay curve (C vs. t).

Table 8.3 shows CT models calibrated with true-batch-EPA and true-batch-EPA+EBMUD data bases. Data simulations with these models are shown in Figure 8.7; in general, there is very good agreement. Model exponents show that increasing pH and DOC will lower CT values, reflecting both the lesser stability of ozone at higher pH values and the ozone demand of DOC. CT values also can be translated to bromate levels by using CT as a variable in bromate prediction models. Table 8.4 shows bromate models with CT as a variable in the model for true-batch-EPA and true-batch-EPA+EBMUD data sets. Data simulations using these models are shown in Figure 8.8. Regression lines suggest overpredictions at lower values and underpredictions at higher values.

Figure 8.9 shows (ultimate) bromate formation as a function of (calculated) CT values for different water sources. The calculated values represent integration of DO_3 vs t curves from $t = 0$ to several selected points along the decay curve. Besides differences in Br^- levels, the fact that, for the same CT values, each water shows different bromate formation suggests that type of DOC in these waters also is important. This CT concept captures the ozone-demand characteristics of the specific DOC present. Figure 8.10 shows (ultimate) bromate formation as a function of CT for different water sources with equal (adjusted) bromide levels. In comparison to Figure 8.9 (variable bromide), there is less divergence in the bromate formation response of the different waters. Nevertheless, while the divergence is less, it is still significant, indicating the influence of (type and amount) of DOC. Even for those plots corresponding to almost equal DOC levels, there are still differences, indicating the influence of type of DOC.

External Validation of Models

External validation of models is important to check validity of the models. External validation involves use of data external to the data base to test the predictive capabilities of models. We elected to use data from several studies summarized in Table 8.5; these include pilot studies (Siddiqui et al., 1993; Krasner et al., 1993) and continuous-flow bench-scale studies (James M. Montgomery Engineers, 1992), conducted over a range of water quality and treatment conditions. Temperature conditions were not considered in these simulations; reaction time was set equal to the hydraulic residence time

TABLE 8.3- PREDICTIVE MODELS FOR CT

a- True Batch Model; EPA Data Only**(Source Waters: BGW, PBW, ISW, SPW, TYA, HMR)**

$$[CT] = 9.2 (\text{DOC})^{-0.809} (\text{pH})^{-1.053} (\text{O}_3)^{1.304} (t)^{0.691}$$

$$R^2 = 0.96, F = 602, N = 116, \alpha < 0.0001$$

b- True Batch Model; EPA+EBMUD Data**(Source Waters: BGW, PBW, ISW, SPW, TYA, HMR, EIS, ESL, EWC, EES)**

$$[CT] = 14.5 (\text{DOC})^{-0.753} (\text{pH})^{-1.266} (\text{O}_3)^{1.265} (t)^{0.677}$$

$$R^2 = 0.96, F = 954, N = 176, \alpha < 0.0001$$

where

CT= (Concentration)(Time) (mg-min/L); $0.7 \leq CT \leq 155$ t = Time (min) ; $1 \leq t \leq 120$ pH; $6.5 \leq \text{pH} \leq 8.5$ DOC= Dissolved Organic Carbon (mg/L) ; $1.1 \leq \text{DOC} \leq 8.4$ O_3 = Transferred/Utilized Ozone (mg/L); $1.1 \leq \text{O}_3 \leq 10$

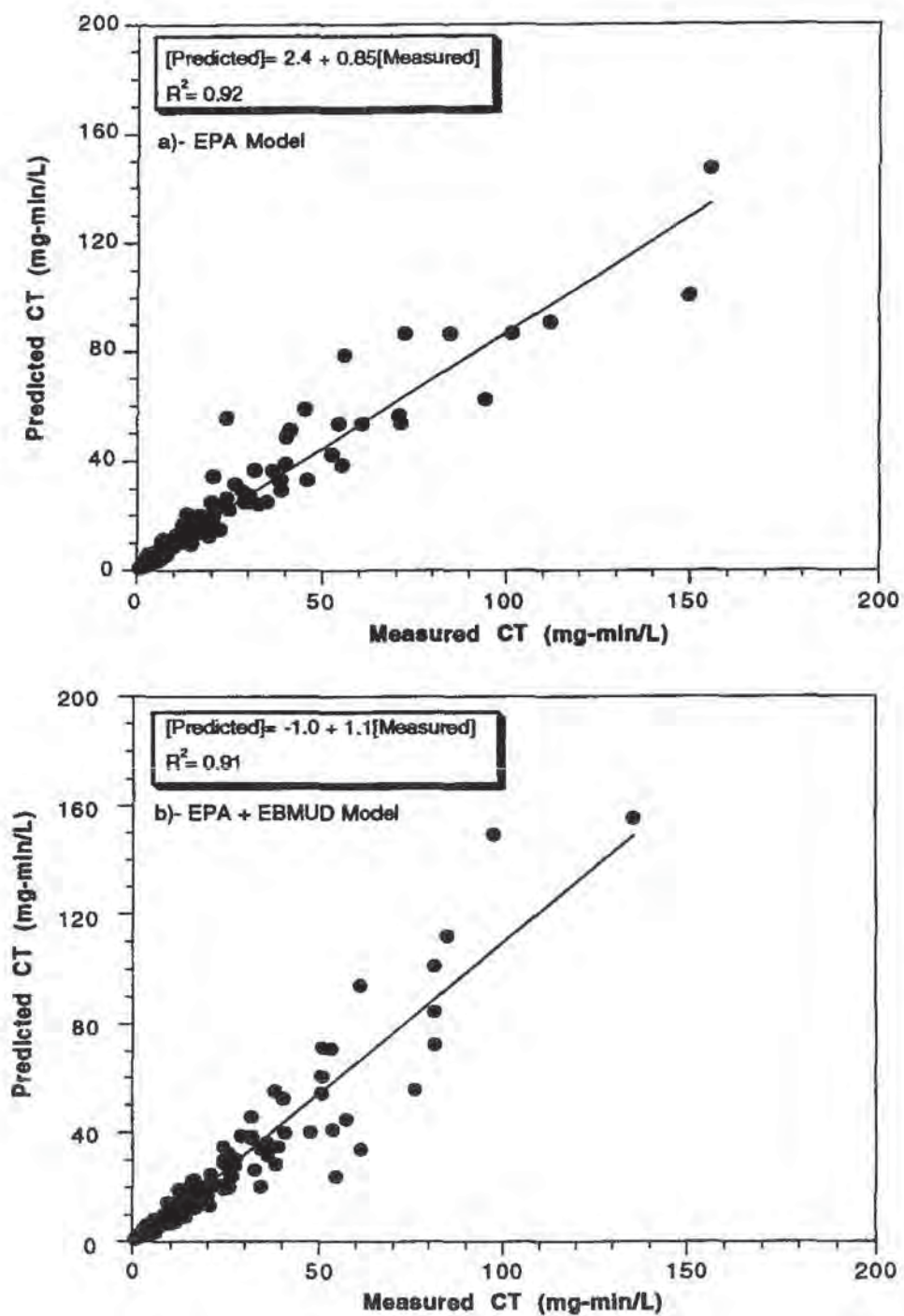


Figure 8.7. Predicted versus Measured CT, True Batch-EPA, and True Batch EPA+EBMUD Models

TABLE 8.4- PREDICTIVE MODELS FOR BROMATE FORMATION WITH CT

a- True Batch Model; EPA Data Only

(Source Waters: BGW, PBW, ISW, SPW, TYA, HMR)

$$[\text{BrO}_3] = 1.0 \times 10^{-6} (\text{DOC})^{-0.368} (\text{pH})^{6.185} (\text{Br})^{0.793} (\text{CT})^{0.553}$$

$$R^2 = 0.7, F = 66, N = 116, \alpha < 0.0001$$

b- True Batch Model; EPA+EBMUD Data

(Source Waters: BGW, PBW, ISW, SPW, TYA, HMR, EIS, ESL, EWC, EES)

$$[\text{BrO}_3] = 3.0 \times 10^{-7} (\text{DOC})^{-0.211} (\text{pH})^{6.818} (\text{Br})^{0.684} (\text{CT})^{0.603}$$

$$R^2 = 0.7, F = 100, N = 176, \alpha < 0.0001$$

where

 BrO_3^- = Bromate ($\mu\text{g/L}$) ; $2 \leq [\text{BrO}_3^-] \leq 314$ Br^- = Bromide ($\mu\text{g/L}$) ; $70 \leq [\text{Br}^-] \leq 440$ t = Time (min) ; $1 \leq t \leq 120$ pH ; $6.5 \leq \text{pH} \leq 8.5$ DOC = Dissolved Organic Carbon (mg/L) ; $1.1 \leq \text{DOC} \leq 8.4$ CT = (Concentration)(Time) (mg-min/L); $0.7 \leq \text{CT} \leq 155$

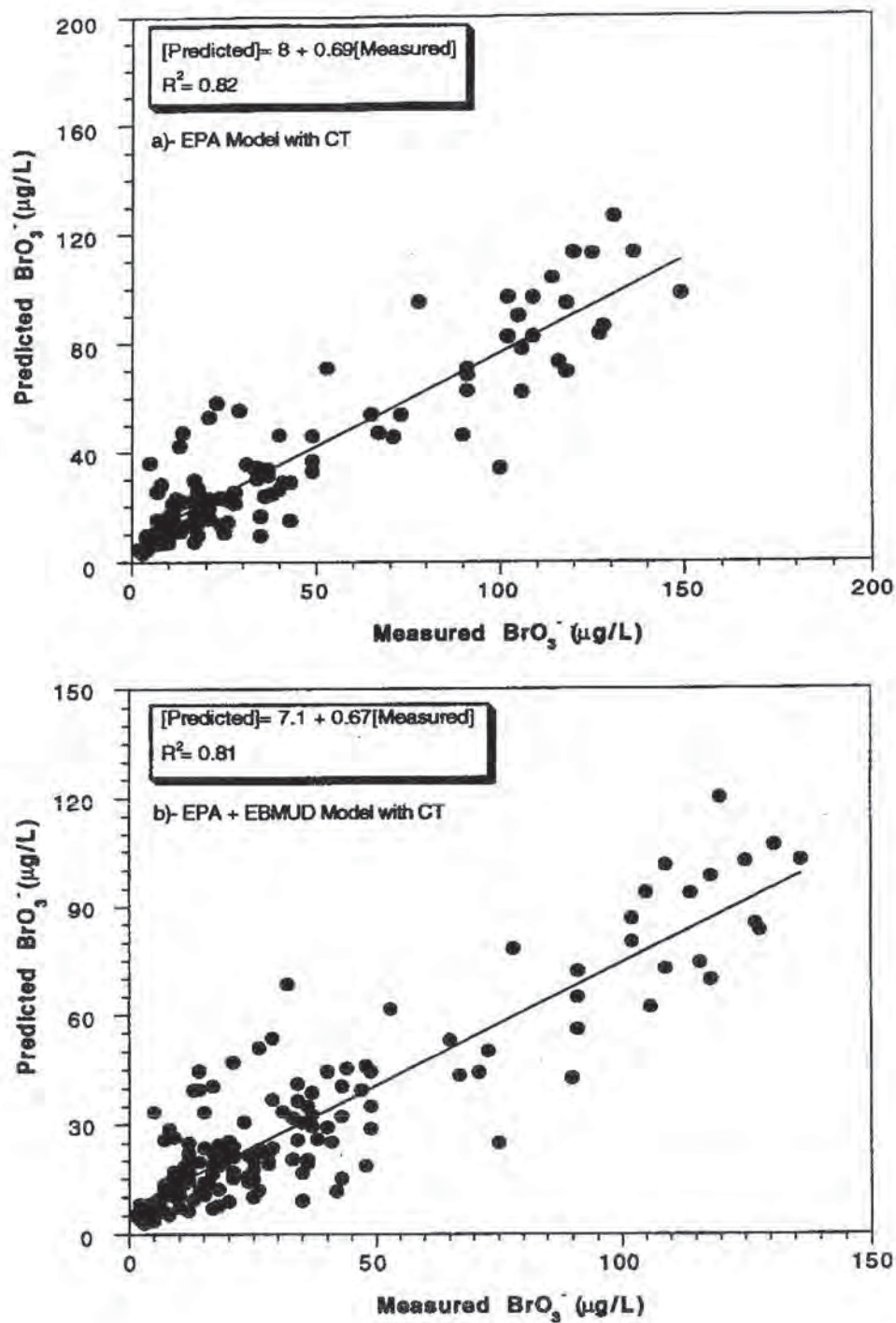


Figure 8.8. Predicted versus Measured Bromate Using True Batch-EPA, and True Batch EPA+EBMUD Models with CT

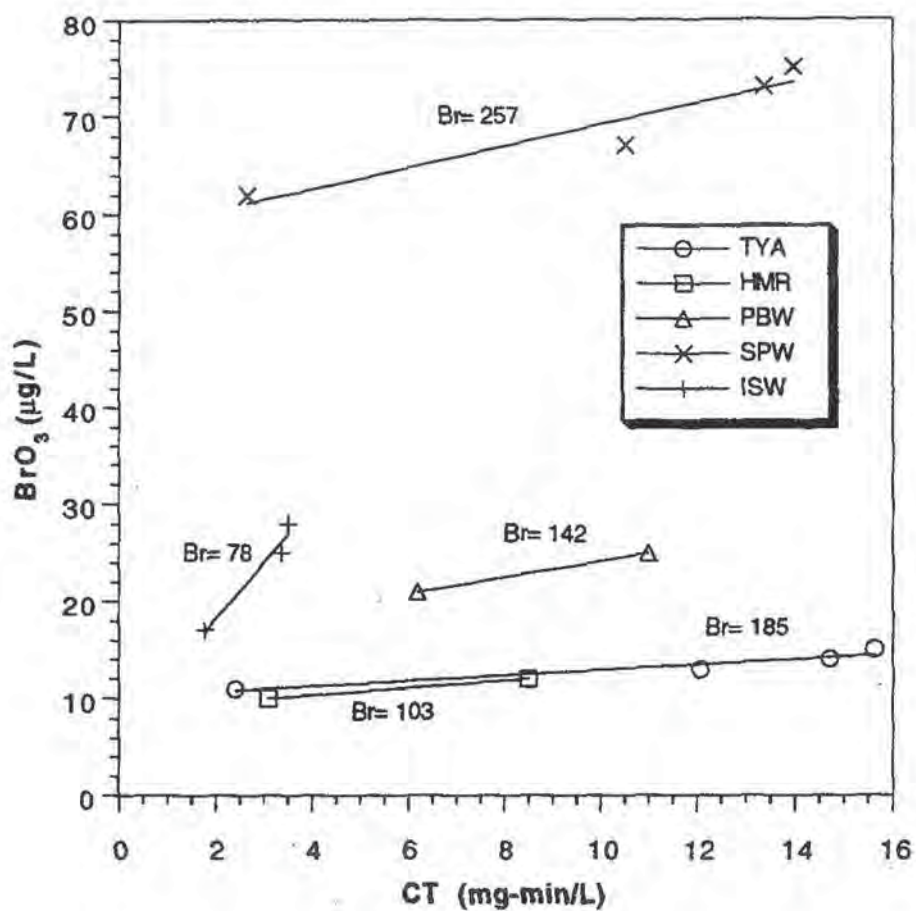


Figure 8.9. Bromate Formation as a Function of Ozone Exposure (C-T); Variable Bromide

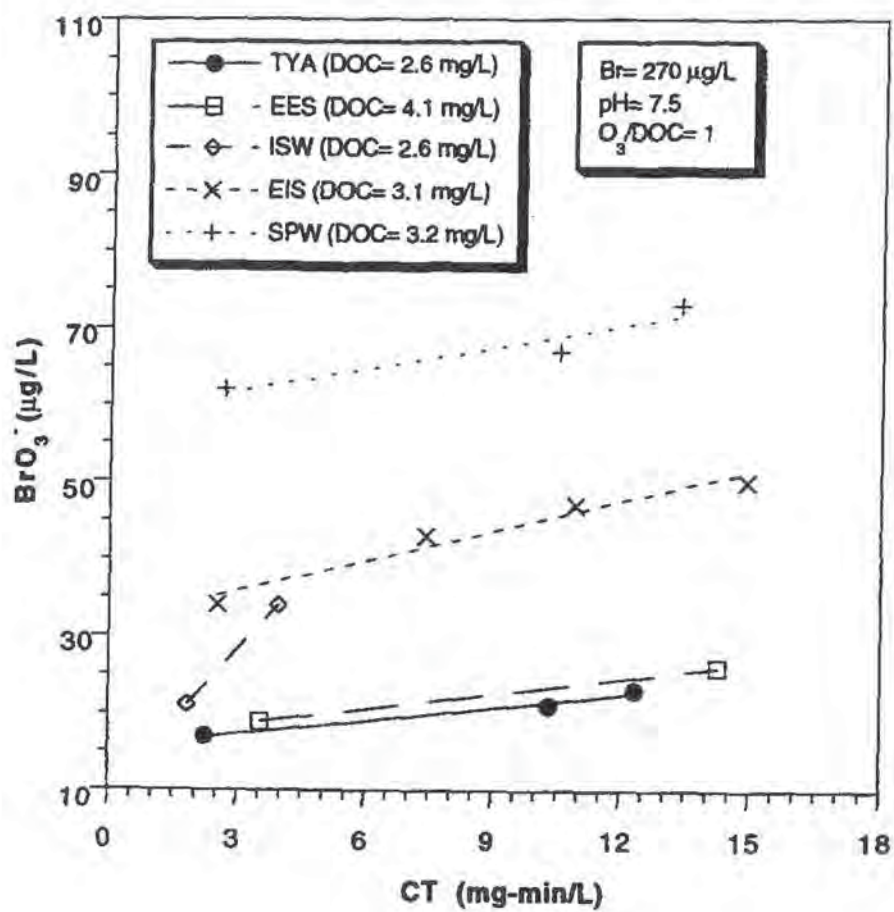


Figure 8.10. Bromate Formation as a Function of Ozone Exposure (C-T); Constant Bromide

TABLE 8.5- EXTERNAL VALIDATION OF MODELS WITH LITERATURE DATA

Water Source	Ref.	pH	Br ($\mu\text{g/L}$)	O ₃ (mg/L)	DOC (mg/L)	Measured BrO ₃ (mg/L)	Predicted EPA	BrO ₃ ($\mu\text{g/L}$) EPA+EBMUD
Utility #4	1	8.0	360	7.81	4.2	148	164	148
		7.0	360	2.35	4.2	8	16	11
		7.0	360	4.45	4.2	32	37	30
Utility #5	1	8.4	90	2.39	5.2	5	8	7
		7.4	90	4.63	5.2	8	12	10.5
Utility #23	1	7.3	400	1.98	3.3	10	23	16
Utility #24	1	7.2	260	0.42	0.6	15	17	11
		7.4	260	0.66	0.6	29	37	27
		8.2	260	0.41	0.6	14	33	21.5
Utility #27	1	8.1	30	9.8	4.5	10	25	29
Utility #30	1	7.3	30	5.1	4.5	6	6	6
Sacramento River Delta	2	7.3	30	9.7	4.5	14	14	16
		8.3	160	6.1	6.6	10	39	33
		6.8	60	6.6	3.7	7	13	14
		8.8	500	4.0	5.5	100	71	53
		8.8	500	4.0	5.5	121	88	65
		6.5	500	4.0	5.5	31	14	11
		6.5	500	4.0	5.5	37	17	13
		8.8	500	2	5.5	32	28	18
Colorado River	3	8.0	290	1	3.3	16	14	9
		8.0	290	2	3.3	28	36	25
		8.0	290	3	3.3	117	63	48
		8.0	290	4	3.3	122	93	76

1- James M. Montgomery Engineers, "Effects of Coagulation and Ozonation on the Formation of Disinfection By-Products", Prepared for AWWA, January 1992.

2- Siddiqui, M., Amy, G., Ozekin, K., Westerhoff, P., Miller, K., "The Role of Tracer Studies in Relating Laboratory and Pilot-Scale Ozonation Data", 11th Ozone World Congress Proceedings, San Francisco, 1993.

3- Krasner, S.W., Gramith, J.T., Coffey, B.M., Yates, R.S., "Impact of Water Quality and Operational Parameters on the Formation and Control of Bromate During Ozonation", International Water Supply Association Proceedings : Bromate and Water Treatment, Paris, November 22-24, 1993.

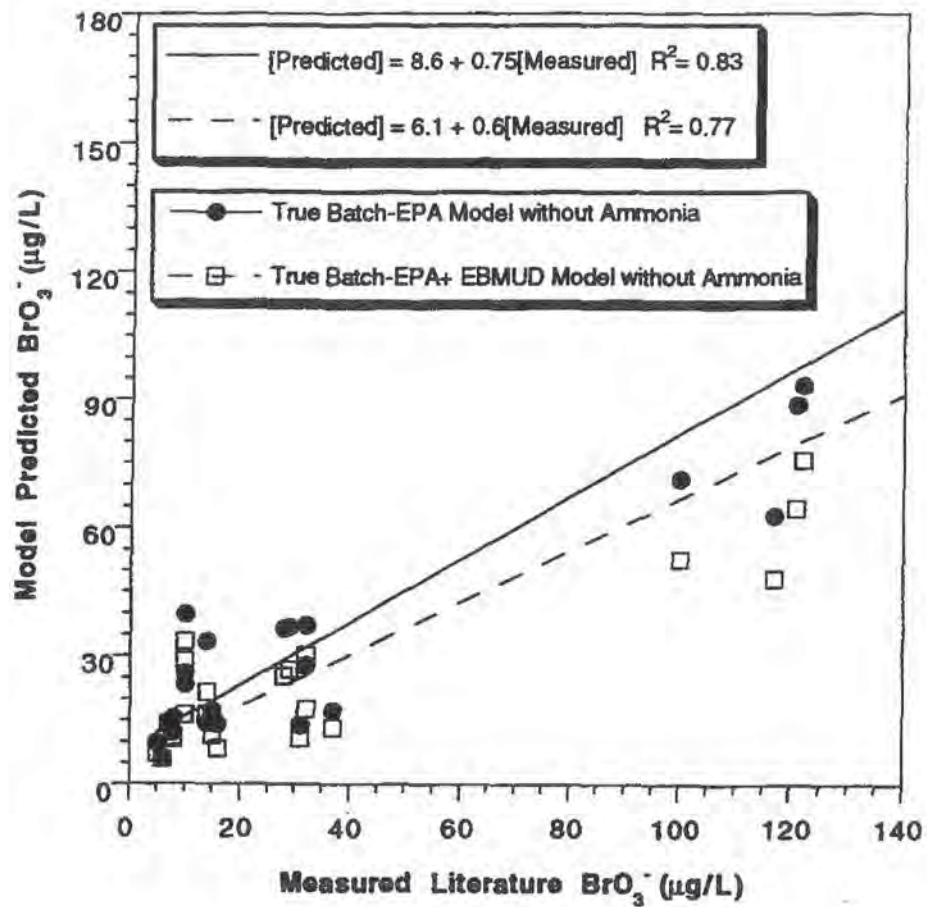


Figure 8.11. External Validation of Models with Literature Data
(Data from Table 8.5)

(HRT); ozone doses are transferred doses; and the data reflect a mix of pre- and intermediate- O_3 tests. Figure 8.11 shows predicted values versus pilot (and continuous-flow bench) scale values for true-batch-EPA (without ammonia) and true-batch-EPA+EBMUD (without ammonia) models. These model predictions show some underprediction at higher values and some overprediction at low values, suggesting reasonably good predictions at intermediate values.

COMPARISON OF TRUE BATCH WITH SEMI-BATCH MODELS

It was previously stated that bromate formation is reactor specific, a premise that can be demonstrated by comparing the semi-batch and true-batch models under the same water quality and operational conditions. Figure 8.12 shows predictions of bromate for different source waters using semi-batch and true-batch-EPA models. These simulations show that the true batch model (and its mode of ozone application) results in greater predictions of bromate formation than the semi-batch model (and its mode of ozone application). The difference can range from as low as 30 % to as high as 100 %. One reason for this difference is that there is a higher driving force (higher DO_3) under true-batch mode of ozone application. Another possible reason is the presence of headspace in the semi-batch system, permitting transfer from the liquid to the gas phase after ozone application has ceased. The hydrodynamics of the reactor and associated mixing conditions are another possible reason for these differences. Still another reason is how reaction time is defined in modeling semi-batch data. The previous predictions applied to pilot-plant data are further revealing in that the true-batch models were reasonably capable of predicting bromate formation under continuous-flow pilot-plant conditions.

Thus, even at the laboratory scale, bromate formation is reactor specific. While the semi-batch mode of application more closely simulates a pilot- or full-scale reactor in terms of continuous ozonation, the DO_3 profile is much different; a continuous-flow system provides a steady state profile across the reactor. The true-batch mode of application results in a time-dependent DO_3 profile which is similar to the space-dependent profile observed in ozone contactors with a point of admission near the contactor entrance. We have found that true-batch models more accurately simulate pilot- and full-scale contactors. Such simulations were discussed in the previous section. Admittedly, part of the poor simulations of the semi-batch reactor may be attributed to its non-steady behavior and our assumptions on how to define the reaction time (defined as post-application herein).

EVALUATION OF CONTROL OPTIONS: MODEL SIMULATIONS

An important attribute of the bromate prediction models is that they allow

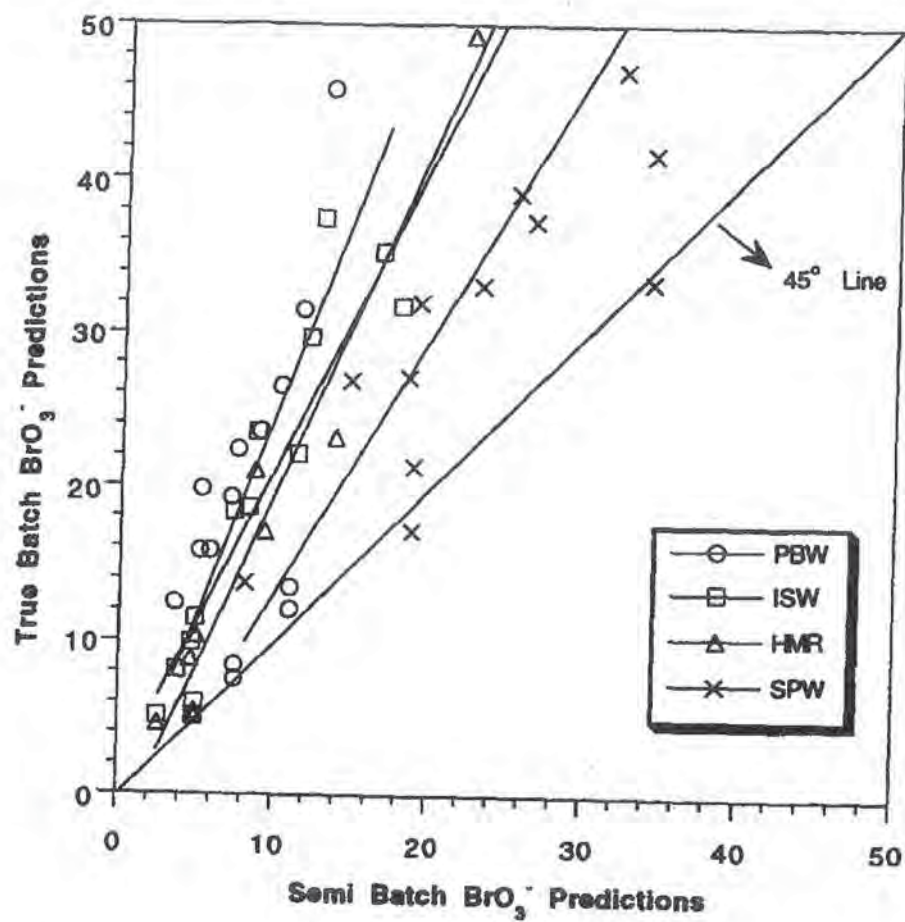


Figure 8.12. Predicted Bromate Using True Batch-EPA Model versus Semi Batch Model

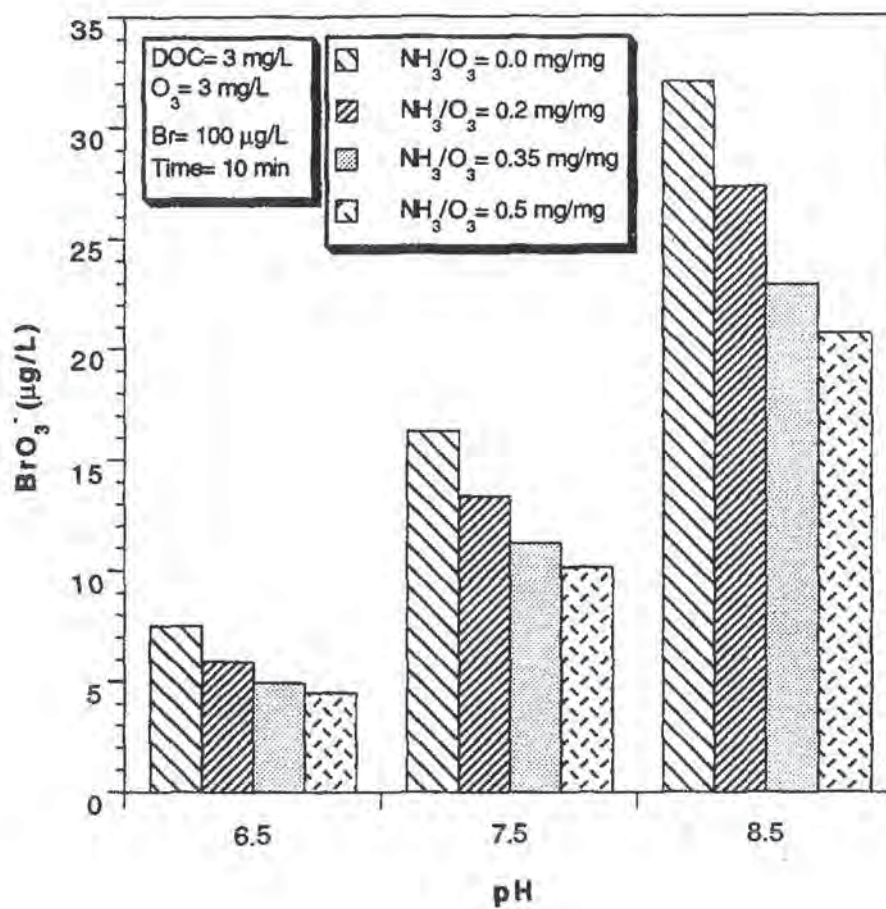


Figure 8.13. Bromate Control Options (Simulations of True Batch-EPA Model)

assessment of bromate control options, including pH depression and ammonia addition. Figure 8.13 shows such simulations based on a defined set of conditions. pH reduction from 8.5 to 7.5 to 6.5 is very influential; the major constraint to such an approach would be the amount of acid required, particularly for high alkalinity waters. Ammonia addition clearly has a lesser effect. These simulations are consistent with control option assessments performed by others, and the designation of pH depression as the best available technology (BAT).

ORGANO-Br FORMATION

In the presence of DOC and Br^- , ozonation of natural waters can lead to organo-Br by-products such as bromoform, bromoacetic acids, bromoacetones, and bromoacetonitriles. Bromoform, one of the brominated organic by-products, can form through reaction of HOBr , acting as a substitution agent, with DOC:



It is evident from above reaction that bromoform formation is influenced by certain water quality and operational/treatment conditions such as pH and the presence of DOC. Figure 8.14 shows the effects of various parameters on bromoform formation. As can be seen from Figure 8.14, bromoform forms only in the case of a relatively high bromide concentration and application of relatively high ozone doses. Considering that the MCL for total THMs is 100 $\mu\text{g/L}$, with a proposal to lower the MCL to 80 $\mu\text{g/L}$, bromoform formation during ozonation will not be a significant problem for water utilities.

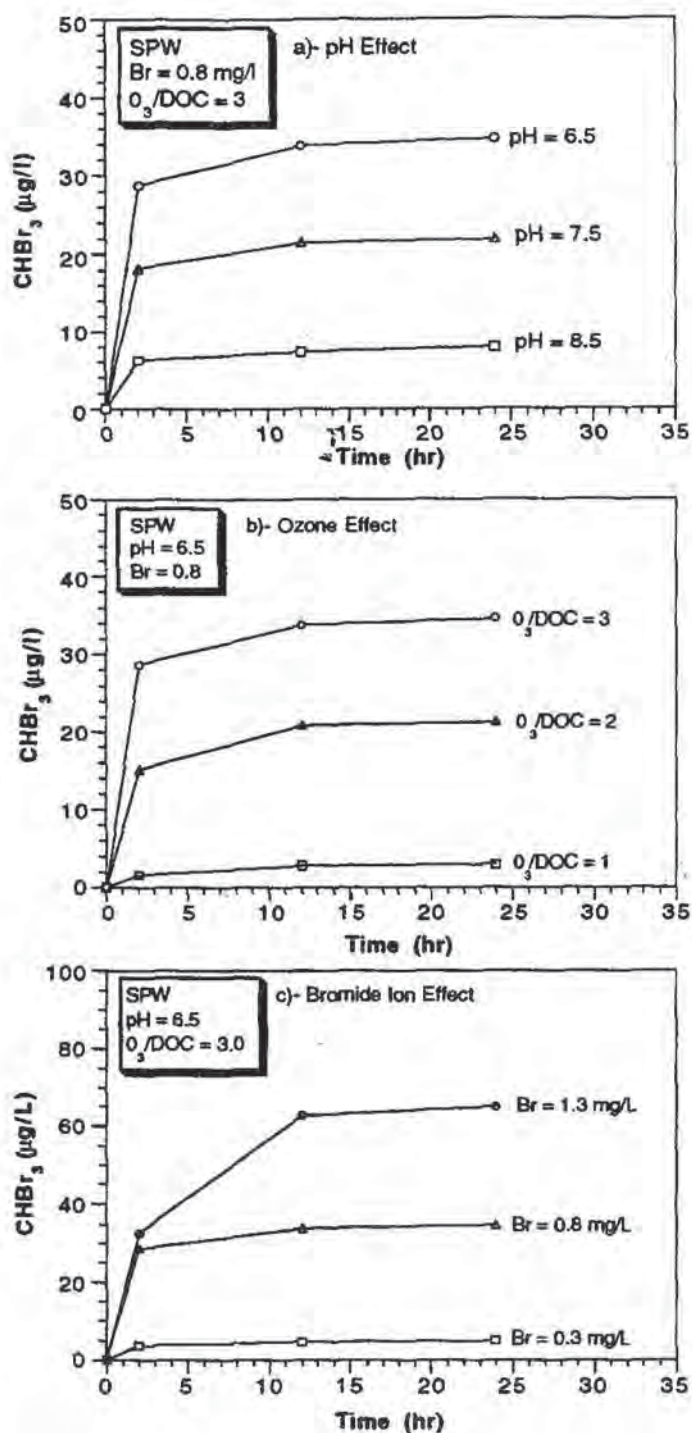


Figure 8.14. Individual Parameter Effects on Bromoform Formation (Semi Batch); Effects of pH, Ozone Dose, and Bromide Ion Concentration

MODEL APPLICATIONS

The models developed herein can be used to assess the ability of water utilities to meet existing and future DBP regulations. These models have most relevance to inorganic ozonation by-products formed under pre-ozonation conditions, and to chlorination by-products formed either before or after significant DBP precursor removal has been accomplished.

CHLORINATION BY-PRODUCT AND CHLORINE DECAY MODELS

The chlorination by-product models can be used to assess both in-plant and distribution system formation of THMs, HAAs (HAA₆), and CH. (As mentioned previously, THAA models correspond to HAA₆; HAA₅ regulated under Stage 1 of the D/DBP Rule can be estimated by summation of predictions the five relevant individual HAA species). Water quality conditions such as DOC, pH, temperature, and bromide are needed as inputs to the models; such data then allow assessment of chlorination DBP formation as a function of reaction time. Within this context, time can reflect the hydraulic residence (HRT) of a chlorine contact basin or the average HRT of a distribution system.

The models can be used to assess pre-chlorination scenarios involving raw/untreated waters. Post-chlorination scenarios can be assessed using either raw/untreated water models, if little precursor removal has been achieved. Otherwise, either treated (coagulated) water models or reactivity-coefficient adjusted raw-water models can be employed (the latter recommended if temperature and pH variations are significant).

Chloramination scenarios involving the sequence of free chlorine followed by ammonia addition can be approximated by considering the lag time between addition of the respective chemicals; such an approximation would simply show DBPs formed in the presence of free chlorine before ammonia addition.

The effects of precursor removal by chemical coagulation can be assessed through use of the treated water models. One can either predict DBPs formed under a given degree of precursor removal, or can define the degree of precursor removal required to meet given DBP regulations. The impact of bromide ion on meeting regulations can also be assessed. If one makes the assumption that precursor reactivity (i.e., DBP/DOC) changes as a function of treatment type, one can also assess other precursor removal processes such GAC or membranes through use of the raw/untreated water models (i.e., ϕ_{GAC} ,

$\phi_{\text{MEMBRANES}}$). Otherwise, if one assumes comparable effects on reductions in precursor reactivity, the coagulated water models can be used to approximate the performance of these other precursor removal processes. Although it can be envisioned that there is a ϕ_{OZONE} , it is recommended that one should not use the models to approximate post-chlorination by-products following an ozonation step, given the complexity of ozone effects on subsequent chlorine reactivity of NOM.

Through use of the chlorine decay models, one can assess CT requirements and CT conditions provided under various water quality conditions. Moreover, the chlorine decay models can be used to assess dosing requirements to ensure maintenance of distribution system residuals.

Another potential application is assessing impacts on DBP formation of the lead and copper rule through the pH parameter.

BROMATE AND OZONE DECAY MODELS

The bromate formation models presented herein can be used to approximate bromate formation under varying water quality (DOC, pH, Br^-) and treatment conditions (O_3 dose). The models can also be used to assess potential control strategies (pH depression, NH_3 addition). The major constraint to such use of these models is that bromate formation has been found to be largely reactor specific. It is the dissolved ozone time/space profile within a reactor which is most influential in determining the degree of bromate formation; these profiles are established through the mode of ozone application and contactor hydrodynamics (mixing). Given the two forms of models developed herein, true-batch and semi-batch, it is the former that comes closer to simulating continuous flow contactors, either at the pilot or full-scale.

The effects of DOC on bromate formation can be assessed to determine ozone point of application; either pre- O_3 before any DOC removal has been realized, or intermediate- O_3 after chemical coagulation has achieved some DOC removal. In applying the models to post-coagulated waters, one must assume (as an approximation) that the character of the DOC remaining after coagulation resembles that of the raw water. The effects of pH, either as a water quality condition or treatment option, can easily be assessed. Those models which include an ammonia term were developed to permit assessment of NH_3 addition. Ozone application strategies such as tapered ozonation can be assessed through stepwise application of the model.

The ozone decay models have relevance in both bromate minimization as well as CT aspects of ozone use. The models can be used to approximate contactor DO_2 residuals expected after a given HRT (or t_{10}).

REFERENCES

- Amy, G.; Chadik, P. and Chowdhury, Z., "Developing Models for Predicting Trihalomethane Formation Potential and Kinetics", Journal AWWA, 79:7:89 (1987a).
- Amy, G.; Minear, R., and Cooper, W., "Testing and Validation of Multiple Linear Regression Model For Trihalomethane Formation Potential", Water Research, 21:649 (1987b).
- Amy, G., et al., "The Effect of Ozonation and Activated Carbon Adsorption on Trihalomethane Speciation", Water Research, 25:2:191 (1991).
- Amy, G., et al., "Threshold Levels for Bromate Formation in Drinking Water", IWSA Proceedings: Bromate and Water Treatment, Paris (1993).
- Amy, G., et al., "Bromide Occurrence: Nationwide Bromide Survey", AWWARF Report (1994).
- APHA, Standard Methods for the Examination of Water and Wastewater (1989).
- Box, G., et al., Statistics For Experimenters, Wiley Interscience (1978).
- Chadik, P., and Amy, G., "Coagulation and Adsorption of Aquatic Organic Matter and Humic Substances: An Analysis of Surrogate Parameters for Predicting Effects on Trihalomethane Formation Potential", Environmental Technology Letters, 87:8:261 (1987).
- Chowdhury, Z.; Amy, G. & Siddiqui, M., "Modeling Effects of Bromide Ion Concentration on The Formation of Brominated Trihalomethanes", Proceedings. AWWA Conference (1991).
- Engerholm, B., and Amy, G., "A Predicative Model for Chloroform Formation from Humic Acids", Journal AWWA 75:8:418 (1983).
- Gordon, G., "The very Slow Decomposition of Aqueous Ozone in Highly Basic Solutions", Proceedings, 8th Ozone World Congress, IOA, Zurich, Switzerland (1987).
- Gordon, G. Cooper, W., Rice, R., and Pacey, G., "Disinfectant Residual Measurement Methods", AWWARF, Research Report (1987).

- Gould, J., Fitchhorn, L., and Urheim, E., "Formation of Brominated Trihalomethanes: Extent and Kinetics", Water Chlorination Environmental Impact and Health Effects/Vol. 4, pp. 297-310, Ann Arbor, MI: Ann Arbor Science Publishers, Inc. (1983).
- Grasso, D., "Ozonation Dynamics in Water Treatment: Autocatalytic Decomposition, Mass Transfer and Impact on Particle Stability", Ph.D. Dissertation, The University of Michigan, Ann Arbor, Mich. (1987).
- Haag, W., and Hoigne, J., "Ozonation of Bromide Containing Waters: Kinetics of Formation of Hypobromous Acid and Bromate", Envir. Sci. Technol., 17:261 (1983).
- Hewes, C., et al., "Kinetics of Ozone Decomposition and Reaction with Organics in Water", A.I.Ch.E., 17:141 (1971).
- Hoigne, J., and Bader, H., "Ozonation of Water: Selectivity and Rate of Oxidation of Solutes", Proceedings, 3rd IOA Congress, Paris, France (1977).
- Hoigne, J., and Bader, H., "Rate Constants of Reactions of Ozone with Organic and Inorganic Compounds in Water: III: Inorganic Compounds and Radicals", Water Res., 19:993 (1985).
- Krasner, S., et al., "The Occurrence Of Disinfection By-Products In U.S. Drinking Water", Journal AWWA, 81: 8:41 (1989).
- Krasner, S., et al., "Impact of Water Quality and Operational Parameters on the Formation and Control of Bromate During Ozonation", IWSA Proceedings: Bromate and Water Treatment, Paris (1993).
- Lynn, S.W. "An Analytical Survey of Chloroform Formed from the Chlorination of Humic Substances", Ph.D. Dissertation, University of Massachusetts (1982).
- Miller, J., and Uden, P., "Characterization of Nonvolatile Aqueous Chlorination Products of Humic Substances", Environ. Sci. Technol. 17:150 (1983).
- Moomaw, C., Amy, G., Krasner, S., and Najm, I., "Predictive Models for Coagulation Efficiency in DBP Precursor Removal", Proceedings, AWWA Conference, pp. 221-233 (1993).

Montgomery Engineers, "Disinfection By-Products Database and Model Project", AWWA Project Final Report, James M. Montgomery, Consulting Engineers, Inc. (1991).

Montgomery Engineers, "Effect of Coagulation and Ozonation on the Formation of Disinfection By-Products", AWWA Project Final Report, James M. Montgomery, Consulting Engineers, Inc. (1992).

Oliver, B., and Lawrence, J., "Haloforms in Drinking Water: A Study of Precursors and Precursor Removal", Journal AWWA, 71:161-163 (1979).

Oliver, B., et al., "Influence of Aquatic Humic Substance Properties on Trihalomethane Potential", Water Chlorination Environmental Impact and Health Effects Vol. 4:1, R.L. Jolley., Ann Arbor, MI: Ann Arbor Science Publishers, Inc., pp. 231-242 (1983).

Ozekin, K., "Modeling Bromate Formation during Ozonation and Assessing its Control", Ph.D. Dissertation, University of Colorado, Boulder (1994).

Qualls, R., and Johnson, D., "Kinetics of the Short-Term Consumption of Chlorine by Fulvic Acid", Environ. Sci. & Technol., 17:692 (1983).

Reckhow, D., and Singer, P., "Mechanisms of Organic Halide Formation During Fulvic Acid Chlorination and Implications with Respect to Preozonation", Water Chlorination: Environmental Impact and Health Effects, Vol. 5, Lewis Publ., Chelsea, Mich. (1985).

Reckhow, D., and Singer, P., "The Removal of Organic Halide Precursors by Preozonation and Alum Coagulation", Journal AWWA, 76:4:151 (1984).

Rook, J., "Formation of Haloforms During Chlorination of Natural Waters", Water Treat. Exam. 23:234-243 (1974).

Roth, J., and Sullivan, D., "Solubility of Ozone in Water", Indus. Engrg. Chem. Fund., 20:137 (1981).

Siddiqui, M., and Amy, G., "Factors Affecting DBP Formation During Ozone-Bromide Reactions", Journal AWWA, 85:1:63 (1993).

Siddiqui, M., et al., "The Role of Tracer Studies in Relating Laboratory and Pilot Scale Ozonation Data", 11th Ozone World Congress, Volume 1: S-2-45

(1993).

Sotelo, J., et al., "Henry's Law Constant for the Ozone-Water System", Water Research, 23:1239 (1989).

Staehelin, J., et al., "Ozone Decomposition in Water Studied by Pulse Radialysis to OH and HO₂ as Chain Intermediates", Jour. Phys. Chem., 88:5999 (1984).

Tomiyasu, H., et al., "Kinetics and Mechanisms of Ozone Decomposition in Basic Aqueous Solution", Inorg. Chem., 24:2962 (1985).

von Gunten, U., and Hoigne, J., "Bromate Formation During Ozonation of Bromide Containing Waters", 11th Ozone World Congress, Volume 1: S-9-42 (1993).

Wang, H., "Empirically Based Kinetic Models for Predicting the Formation of Chlorination By-Products: Haloacetic Acids", M.S. Thesis, University of Colorado, Boulder (1994).

Weis, J., "Investigation on the Radical HO₂ in Solution", Trans. Faraday Soc., 31:668 (1935).

Zhu, H., "Modeling the Effects of Coagulation on Chlorination By-Product Formation", Ph.D. Dissertation, University of Colorado, Boulder (1995).

Water Quality Objectives in the San Francisco Bay/



United States
Environmental Protection
Agency

Unabridged Advanced Notice of Proposed Rulemaking

February 2011

**Unabridged Advanced Notice of Proposed Rulemaking for
Water Quality Challenges in the San Francisco Bay/
Sacramento-San Joaquin Delta Estuary**

February 2011

**United States
Environmental Protection Agency**

Summary

The U.S. Environmental Protection Agency (EPA) is publishing an advance notice of proposed rulemaking (ANPR) to seek comments from interested parties on possible EPA actions to address water quality conditions affecting aquatic resources in the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (Bay Delta Estuary) in California. EPA is asking the public to consider broadly whether EPA should be taking new or different actions under its programs to address recent significant declines in multiple aquatic species in the Bay Delta Estuary. EPA is not limiting its request to actions that would require rulemaking. There may be a range of changes in EPA's activities in the Bay Delta Estuary that would be constructive, including enforcement, research, revisions to water quality standards, etc. EPA will consider all comments before deciding what changes, if any, should be pursued. After reviewing the comments and completing its evaluation, EPA will provide the results of its review and any proposed next steps to the public. This ANPR identifies specific issues on which EPA solicits comment, including potential site-specific water quality standards and site-specific changes to pesticide regulation. In addition to the specific issues on which EPA solicits comments, EPA is interested in comments on any other aspects of EPA's programs affecting Bay Delta Estuary aquatic resources.

This ANPR has no regulatory impact or effect. The ANPR contains descriptions of certain EPA programs relevant to the Bay Delta Estuary and poses questions about how these programs could better protect and improve water quality for the benefit of aquatic resources in the Bay Delta Estuary. This ANPR marks the beginning of a process to consider possible changes to EPA programs in the Bay Delta Estuary.

If EPA decides to pursue regulatory changes as a result of this ANPR, those regulatory changes will be made pursuant to appropriate formal rulemaking procedures. If changes to any regulations, rules, guidance or statutes are proposed and ultimately made final, to the extent such changes would require and/or authorize changes to state or tribal water quality standards or other regulations, states or authorized tribes would be affected. If changes to state or tribal regulations result from any final rule that EPA may promulgate in the future, entities subject to compliance with state or tribal regulations would also potentially be affected. For example, states and tribes authorized to implement the National Pollutant Discharge Elimination System (NPDES) Permit Program would need to ensure that permits they issue include any limitations on discharges necessary to comply with any water quality standards established as a result of any subsequent final rulemaking. Therefore, entities discharging pollutants to waters of the United States under NPDES could be affected by subsequent proposed and final rulemaking.

Submitting Comments

Written comments must be received by EPA within 60 days of publication in the Federal Register.

Written comments may be submitted electronically at the *Federal Rulemaking Portal* (www.regulations.gov), identified by docket number EPA-R09-OW-2010-0976. Hard copy comments should be addressed to Erin Foresman, U.S. Environmental Protection Agency, 75 Hawthorne Street, WTR-3, San Francisco, California 94105.

All comments will be included in the public docket without change and will be made available online at www.regulations.gov, including any personal information provided, unless the comment includes Confidential Business Information (CBI) or other information whose disclosure is restricted by statute. Information that you consider CBI or otherwise protected should be clearly identified as such and should not be submitted through www.regulations.gov or e-mail. *Regulations.gov* is an “anonymous access” system and EPA will not know your identity or contact information unless you provide it in the body of your comment. If you send email directly to EPA, your e-mail address will be automatically captured and included as part of the public comment. If EPA cannot read your comment due to technical difficulties and cannot contact you for clarification, EPA may not be able to consider your comment.

Docket: The index to the docket for this action is available electronically at www.regulations.gov and in hard copy at EPA Region 9, 75 Hawthorne Street, San Francisco, California. While all documents in the docket are listed in the index, some information may be publicly available only at the hard copy location (e.g., copyrighted material), and some may not be publicly available in either location (e.g., confidential business information). To inspect the hard copy materials, please schedule an appointment during normal business hours with Erin Foresman, foresman.erin@epa.gov; (916)557-5253.

For further information contact: Erin Foresman at U.S. Environmental Protection Agency, Region 9, Water Division, 75 Hawthorne Street, San Francisco, California 94105; foresman.erin@epa.gov; (916)557-5253.

Table of Contents

I. PURPOSE OF THIS ANPR	1
II. INTRODUCTION TO EPA ACTIVITIES IN THE BAY DELTA ESTUARY	5
A. Factual Background	5
1. Current State of Estuarine Resources.....	5
2. Defining a Functional Estuary in a Changing Environment	10
B. EPA Programs in the Bay Delta Estuary	11
1. Clean Water Act.....	11
a. Water Quality Standards	11
b. Point Source Regulation	13
c. Total Maximum Daily Loads (TMDLs).....	15
d. Nonpoint Source Management Program	16
e. National Estuary Program	17
f. Wetlands Program	17
g. State Water Quality Certification Program	18
2. Pesticide Regulation under the Clean Water Act and FIFRA	18
III. PROGRAM AREAS FOR PUBLIC COMMENT	20
A. Contaminants	20
1. Request for Public Comment	22
2. Ammonia: Toxic and Nutrient Effects.....	22
a. Aquatic Resource Issues	22
b. Regulatory Status.....	26
i. Water Quality Standards.....	26
ii. Point Source Ammonia Discharges	27
iii. Nonpoint Source Ammonia Discharges	29
c. Request for Public Comment	29
3. Selenium	30
a. Aquatic Resource Issues	30
b. Regulatory Status.....	31
i. Water Quality Standards.....	31
ii. TMDLs and Implementation	33

c. Request for Public Comment	35
4. Pesticides	36
a. Aquatic Resource Issues	36
b. Regulation under FIFRA.....	40
c. Regulation under the Clean Water Act	41
i. Water Quality Standards.....	41
ii. TMDLs	42
iii. Regulation of Agricultural Discharge.....	43
iv. Stormwater Permits	44
v. General NPDES Permits for Aquatic Pesticide Application	46
d. Request for Public Comment	46
5. Contaminants of Emerging Concern.....	48
a. Aquatic Resource Issues	48
b. Regulatory Status.....	49
c. Voluntary Activities	50
d. Request for Public Comment	50
B. Protecting Estuarine Habitat, Fish Migration Corridors and Wetlands.....	52
1. Estuarine Habitat.....	52
a. Aquatic Resource Issues	52
b. Regulatory Status.....	54
c. Request for Public Comment	56
2. Fish Migration Corridors	57
a. Aquatic Resource Issues	57
b. Regulatory Status.....	59
c. Request for Public Comment	61
3. Wetlands	62
a. Aquatic Resource Issues	62
b. Regulatory Status.....	62
c. Request for Public Comment	63
IV. EXECUTIVE ORDER 12866, Regulatory Planning and Review.....	64
V. END NOTES	65

3. Selenium

a. Aquatic Resource Issues

Selenium is a naturally occurring element that, when mobilized in the environment and transformed to organic, bioavailable forms, is highly bioaccumulative.¹⁶¹ Although selenium is a micronutrient, it is highly dose-sensitive and can be toxic to organisms at very low levels of chronic exposure.¹⁶² Selenium toxicity in fish and wildlife reduces reproductive success through effects that lower embryo survival, such as deformed growth (teratogenesis).¹⁶³ In California, the damaging consequences of toxic levels of selenium first came to public attention in the 1980s when deformed waterfowl were discovered at Kesterson Reservoir in the San Joaquin Valley. Subsequent research has substantially advanced understanding of selenium sources and mobilization in the Bay Delta Estuary, the processes through which selenium enters and builds up in the ecosystem, and the effects of selenium on different species. In particular, this science points to the role of site-specific conditions, such as hydrology, geochemistry, food web, and species characteristics in determining risk to aquatic life and wildlife.¹⁶⁴ The new information raises significant questions as to whether the existing regulatory regime adequately protects aquatic life and wildlife.¹⁶⁵

Selenium is naturally present in certain soils of marine origin and can enter the environment when precipitation introduces the selenium-bearing deposit to water. Environmental problems with selenium typically occur when large amounts are mobilized through human activities such as irrigation, mining or processing of organic fuels. Once converted to an actively bioavailable form, selenium tends to stay in a bioavailable form – a characteristic that contributes to build up in the environment over time.¹⁶⁶ Selenium has several dissolved forms (notably selenate, selenite and organo-selenide) that differ in transformation rates and bioavailability. The least bioavailable form, selenate, can be reduced by organisms to selenite and then incorporated into cells as organo-selenium.

Aquatic food webs can be particularly efficient in taking up selenium and transferring it up the food web. At the base of the food web, microorganisms such as bacteria and algae take in and assimilate selenium from ambient water. Since biotic exposure to selenium occurs through diet, rates of exposure are affected by concentrations in species' food sources. Some prey species bioaccumulate selenium more efficiently than others. For example, *Corbula amurensis*, an introduced clam that occurs from San Pablo Bay through Suisun Bay and Marsh and the central and southern Delta, accumulates selenium at roughly three times the rate of supplanted native clam species.¹⁶⁷ As a result, predator species that feed on *Corbula*, such as diving ducks (scaups and scoters) and white sturgeon, suffer high exposure to bioaccumulated selenium. In contrast to the Delta-dwelling white sturgeon, green sturgeon are more sensitive to selenium but spend less time in the Bay and Delta waters; compared to white sturgeon, green sturgeon spend more time in marine waters and also upstream of the Delta in the Sacramento River.¹⁶⁸ In addition to duration of exposure, timing of exposure relative to sensitive life stages can be a factor in impacts. For example, concerns have been expressed about the possibility that juvenile salmon, which use the Delta and San Joaquin River, might be sensitive to selenium.¹⁶⁹

Biological variables, such as species sensitivity to selenium and preferred habitat and

diet, are among the reasons that water column concentration of selenium is not in itself a reliable indicator of exposure. Differences in hydrologic conditions and associated water chemistry also affect the degree to which selenium accumulates at a given site. Where waters are relatively still and flushing is limited (lentic systems), conditions promote build-up of the more bioavailable forms of selenium such as selenite. In flowing rivers or streams (lotic systems) both the flushing function of flows and the typical form of selenium (selenates) limit uptake.

The main controllable sources of selenium in the Bay Delta Estuary are agricultural drainage (generated by irrigation of seleniferous soils in the western side of the San Joaquin basin) and discharges from North Bay refineries (in processing selenium-rich crude oil from the southern San Joaquin Basin). Both the San Joaquin River and North Bay selenium loads have declined in the last 15 years in response to, first, a control program in the San Joaquin Grasslands area, and, second, NPDES permit requirements established for refineries in the late 1990s.¹⁷⁰ The annual loads of selenium (mostly as selenate) entering the Bay Delta Estuary from the San Joaquin and Sacramento rivers vary by water year (that is, by flow), but dissolved selenium loadings averaged 2,380 kg/year from the San Joaquin and 1,630 kg/year from the Sacramento in the 1990-2007 period.¹⁷¹ The Sacramento River selenium concentration, however, is essentially at background levels (.06 +/- .02 micrograms/L), without evidence of significant controllable sources.

Pollutant loading, transport, and residence time in the Bay Delta Estuary could change appreciably as a result of actions that are under consideration or being implemented. These actions include increases in San Joaquin River flows to restore the river and salmon runs, changes in water supply conveyance and related channel flow in the Bay Delta Estuary, and habitat restoration projects within the Bay Delta Estuary. San Joaquin River restoration or other flow augmentation programs could change the capacity of flows to mobilize and transport selenium-rich water and suspended sediments into the Bay Delta Estuary. Within the Bay Delta Estuary, exposure to selenium could increase in planned restoration habitats such as wetlands and floodplains. Thus, while the actions may have beneficial ecosystem and/or water supply objectives, there is some risk of exacerbating the impacts of selenium unless corrective measures are taken.

b. Regulatory Status

i. Water Quality Standards

EPA promulgated ambient water quality criteria for selenium in the Bay Delta Estuary and watershed through the National Toxics Rule (NTR) in 1992. The National Toxics Rule values are reiterated in the California Toxics Rule, issued by EPA in 2000.¹⁷² Subsequently, the California Toxics Rule and Water Boards' Basin Plan amendments have established consistent values for aquatic life. The applicable chronic aquatic life criterion (5 micrograms/L chronic exposure (four day average) measured as a water column concentration) is used more frequently than the acute value.¹⁷³ In the Grasslands waterways and Salt Slough, a more protective chronic value of 2 micrograms/L applies in consideration of sensitive listed species. The lentic conditions of water in the marshes were also a factor in setting these site-specific objectives.¹⁷⁴

The existing criteria for waterbodies listed in the table below, –Current Water Quality

Standards,” refer to longer-term (chronic) and short-term (acute) exposure of aquatic life to selenium. The numbers represent water column concentrations of dissolved selenium and suspended particulates. All criteria listed below are set for aquatic life. The more stringent criteria in the Grasslands marshes and nearby areas are intended to protect threatened and endangered species.

Current Water Quality Standards

LOCATION	CRITERIA		REGULATORY ACTION
	(Chronic)	(Acute)	
San Francisco Bay, including Suisun Bay and Marsh; Delta	5 microg/L – 4 day average	20 microg/L – 1 hr max	National Toxics Rule – 1992
San Joaquin River from Merced River to Vernalis	5 microg/L – 4 day average	12 microg/L – max instantaneous	Cent. Valley Region Basin Plan – 1996; National Toxics Rule – 1992 (chronic only)
Mud Slough; San Joaquin River from Sack Dam to Merced River	5 microg/L – 4 day average	20 microg/L – max instantaneous	Cent. Valley Region Basin Plan – 1996; National Toxics Rule – 1992
Grasslands marshes; Los Banos State WMA; San Luis NWR; Salt Slough	2 microg/L – monthly mean	20 microg/L – max instantaneous	Cent. Valley Region Basin Plan – 1996

The current selenium standards lack criteria specific to water-dependent wildlife,¹⁷⁵ do not account systematically for differences in the physical and chemical characteristics of waterbodies (e.g., lentic versus lotic water)¹⁷⁶ and use a measure (water column concentration, determined through dose-response tests) that is not a consistent indicator of exposure and environmental risk, because it fails to account for variables such as food web characteristics¹⁷⁷. Water column values developed in a dose-response methodology, for example, do not take into account the relative efficiency of food webs in concentrating selenium. An ‘efficient’ food web would be one involving a selenium-sensitive species with a diet including a selenium-concentrating species (e.g., the clam, *Corbula*). Over the last decade EPA has been working with other agencies to expand the scientific knowledge of selenium and update regulatory tools.

Establishing a framework for regulating selenium that integrates protective requirements and implementation across a diverse watershed is challenging. For example, standards set to protect designated uses in lotic (flowing) systems may not protect downstream designated uses in a different environment in terms of hydrology, water chemistry, and food web relationships. Higher river flows can function to transport large, albeit dilute, loads of selenium that settle in quieter downstream locations susceptible to food web uptake. Recently presented data on concentrations of selenium in North Bay clams, which do not show a clear-cut decline in selenium despite reductions in water column concentrations in San Joaquin River water entering the Bay Delta Estuary, suggest that more information is needed to determine the relationship between river inputs and processes in the downstream environment that affect biotic uptake.¹⁷⁸

Several efforts are underway to revise and expand standards for selenium in the Bay Delta Estuary. At the national level, EPA plans to propose Clean Water Act Section 304(a) selenium guidance criteria for aquatic life for freshwater. The guidance criteria will include

chronic values only, and will distinguish between flowing and standing waters. These guidance criteria will form the basis for adopting protective water quality standards expressed as tissue concentration of selenium in fish egg or ovary and a corresponding water column concentration, where tissue concentration data are not available. Concentrations in tissue, such as bird eggs or fish tissue, better indicate actual exposure and, in combination with food web information, provide a basis for deriving site-specific numeric water column values.

The revised national guidance criteria will be supplemented by regional efforts. EPA Region 9, in conjunction with the USGS, USFWS, and NMFS, and pursuant to its obligations under the ESA, is developing criteria to protect threatened and endangered wildlife species, aquatic-dependent species and aquatic life in California. The first phase of this effort addresses the San Francisco Bay and Delta. It uses data on affected species and relies on the Presser-Luoma ecosystem-based model, a model that accounts for food web processes and site-specific conditions.¹⁷⁹ This phase is scheduled for completion in 2011, followed by a second phase for statewide criteria (including the San Joaquin River and its tributaries).

ii. TMDLs and Implementation

North San Francisco Bay, a three-mile reach of the San Joaquin River between Mud Slough and the Merced River confluence (downstream), and the six-mile reach of Mud Slough North downstream of the San Luis Drain are each listed as impaired for selenium.¹⁸⁰ These Clean Water Act listings, which appear in the 2010 Integrated Report, are based principally on evidence of ambient selenium exceeding concentration-based standards.¹⁸¹ Reductions in selenium discharges from agriculture in the San Joaquin Basin have been a major factor in meeting water quality objectives in the San Joaquin River between the Merced and Vernalis. Based on this evidence, the State Board recently declined to list this section of the River but retained the listing for selenium impairment in the reach with lower flow between Mud Slough and the Merced River.¹⁸² Delta waters are not considered impaired for selenium at the present time, largely on evidence of water column concentrations.

North Bay

Compliance with NPDES permit requirements by the oil refineries that discharge selenium in the North Bay has led to reduced loads and shifted the form of discharge towards selenate, rather than selenite.¹⁸³ Estimates of selenium loadings prior to improvements required in 1998 are in the range of 1700-2900 kg/year; improved wastewater treatment post-1998 has reduced loadings to an estimated 200 to 550 kg/year.¹⁸⁴ In March 2010, the San Francisco RWQCB amended four refinery permits, setting limits for total selenium, with a range from 34-50 micrograms/L maximum daily, and 33-42 micrograms/L average monthly. The limits are based on a 10:1 dilution credit, with reference to the 5 microgram/L NTR criterion.¹⁸⁵ The permit for a fifth refinery was amended in late 2009 to require similar limits.

These point sources are also incorporated into a TMDL being developed for selenium in the North Bay. The San Francisco RWQCB began work on the TMDL in 2007 and is now coordinating the schedule and completion date with the forthcoming EPA wildlife criteria and aquatic life guidance criteria. While there are some nonpoint sources within the North Bay

watersheds, the two major anthropogenic sources of North Bay selenium are the point source refineries and agricultural drainage from the San Joaquin Basin.

San Joaquin Grassland Bypass Project

The Grasslands Bypass Project, located west of the San Joaquin River and spanning the boundary between Merced County on the north and Fresno County to the south, is the current focus for implementation of selenium controls in the San Joaquin Basin. This 97,000-acre area is the northern portion of the much larger drainage problem area (730,000 acres total) described in the federal document, San Luis Unit Drainage Feature Reevaluation.¹⁸⁶ The watershed affected by the Grasslands Bypass Project encompasses both irrigated agriculture and extensive private and publicly managed wetlands. Begun in 1995, the Project is significant because it includes most of the lands that discharge subsurface drainage to the San Joaquin River and Bay Delta Estuary.¹⁸⁷

The Grasslands Bypass Project is designed to achieve immediate protection of sensitive wetlands by routing agricultural drainage water away from this habitat into the federal San Luis Drain (a lined drainage canal) and from there into Mud Slough. Six miles downstream of this discharge point, Mud Slough enters the San Joaquin River at a reach with typically low flows. Over time, selenium load reductions implemented by the Grasslands drainers are intended to lead to fully meeting water quality objectives for all waters, including Mud Slough and the San Joaquin River.

Three TMDLs, adopted between 1999 and 2002, are being implemented through the Grasslands Bypass Project.¹⁸⁸ The regulatory framework laid out in the Basin Plan (and reinforced by conditions in a Waste Discharge Requirement) sets immediate compliance for the marshes and Salt Slough (2 ppb, monthly mean) and allows a longer period to meet existing standards for Mud Slough and the River (5 ppb, 4 day average).¹⁸⁹ Some of the implementation framework is also provided in an Agreement for use of the Drain that has been negotiated between the U.S. Bureau of Reclamation (USBR) and the Delta-Mendota Water Authority.¹⁹⁰

Implementation through drainage re-routing and reduction of selenium loads has resulted in meeting water quality objectives in the wetlands and Salt Slough and a 130 mile stretch of the San Joaquin River. Between 1996 and 2007, relying largely on control measures such as reduced water application, water conservation, and water recycling and use on salt tolerant crops, the project managers have reduced selenium loading to surface waters by approximately two-thirds.¹⁹¹ The Project has not, however, achieved the load reductions needed to fully meet the objectives by the compliance date of October 2010 set by the Central Valley RWQCB. During the 15-year project period, the project managers have tested various technologies beyond on-site drainage management to meet selenium load-reduction targets but recently reported to the Central Valley RWQCB that full success in meeting the October 2010 date was hampered by delays in expected state funding assistance and technical difficulties with treatment technologies.¹⁹² In a request to the State to extend the compliance period until 2019, the project managers expressed intent to introduce drainage treatment and disposal technologies that would result in eliminating discharges to the San Joaquin River, provided the funding and treatment technology issues are resolved. In approving this extension, the Water Boards emphasized that

the Project is subject to a prohibition of discharge in 2019. Additionally, the project managers were directed to submit a progress report by January 2013 that includes a plan for compliance with the discharge prohibition and water quality objectives, even if drainage treatment is not found to be a feasible solution.¹⁹³

Controlling selenium, once mobilized, is problematic. Feasible techniques for removal from the biotic system are not evident. Various approaches to removing selenium from water have been tested since Kesterson (e.g., use of algae or bacteria to remove selenium from water, resulting in bioavailable forms that can pose a disposal problem). Currently, membrane technologies (reverse osmosis) are also being investigated.

The amount of selenium stored in the San Joaquin Basin is such that contamination in the Basin and Delta can be expected for years - possibly centuries.¹⁹⁴ Unlike contaminants that can be readily reduced by ending use, selenium is now so widely distributed through the groundwater of the west side of the San Joaquin Basin that it can continue to be a problem even with efficient agricultural irrigation and drainage activities. The situation suggests a need for sustained management and regulatory strategies, as well as a continued commitment to research and assessment.¹⁹⁵

c. Request for Public Comment

Many activities discussed in this notice are already the subject of a formal or informal rulemaking process conducted by either EPA or a related state or federal agency. Nothing in this notice is intended to supersede those ongoing processes, nor does this notice constitute a decision under any of those processes. If commenters have submitted material in connection with those other processes that is believed to be relevant to the issues raised in this notice, the commenter may either reference the earlier submission (if it was submitted to EPA), attach the earlier submission (if it was submitted to a different agency), or, if appropriate, provide a link to the material online.

Please provide the reason(s) for answers to the following questions and scientific, policy, and/or legal information and citations that support your comments.

1. What, if any, additional information is available to better characterize selenium sources, loadings and impacts within the watershed of the Bay Delta Estuary?
2. What data, studies, and analytical techniques (for example, models) could be used to improve our understanding of the physical processes, including surface-groundwater interactions, controlling selenium mobilization and transport to and within the Bay Delta Estuary?
3. What data are needed to track selenium impacts in the Bay Delta ecosystem as currently configured, and to evaluate potential impacts of selenium under changed flow and transport conditions into and within the Delta?

4. Are there additional selenium control methods or programs that should be considered for reducing selenium inputs and impacts?

4. Pesticides

a. Aquatic Resource Issues

General Information

Pesticides are any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating pests. They include products such as insecticides, herbicides, fungicides, rodenticides, piscicides, and antimicrobials. Pesticides are applied indoors and outdoors to structures and landscapes, in urban, suburban and agricultural areas. They are used to control disease-causing or other harmful organisms, including rodents, insects, and weeds that threaten crops and property. Pesticides can, however, present a risk to human health and the environment because they are designed to adversely affect living organisms.¹⁹⁶

Pesticides can cause water quality problems when they are deposited into aquatic environments where they are potentially toxic to non-target organisms. Pesticides may be transported to aquatic sites long distances from application areas by precipitation and overland flow, irrigation runoff and return flow, POTW and stormwater discharges, and atmospheric drift. The USGS National Water Quality Assessment Program analyzes surface waters throughout the United States for pesticides and found that 100% of streams examined contained at least one pesticide; more than 56% of surface water samples contained one or more pesticides in concentrations exceeding aquatic-life benchmarks.¹⁹⁷

Pesticides in the Bay Delta Estuary

More than twenty years of water quality monitoring show pesticides present in California's Central Valley waterways, including the Bay Delta Estuary, at concentrations that affect aquatic ecosystems.¹⁹⁸ The Central Valley RWQCB measured insecticides in irrigation return flows and receiving waters and established a connection between elevated pesticide levels and toxicity events in the Sacramento and San Joaquin Rivers and the Bay Delta Estuary beginning in the late 1980's. This work documented many toxicity events related to pesticide loadings including: (1) toxicity to striped bass (*Morone saxatilis*) larvae, local invertebrate (*Neomysis mercedis*) and standard test invertebrate (*Ceriodaphnia dubia*) in the Sacramento River during 1987-1990 from rice irrigation return flows;¹⁹⁹ (2) invertebrate toxicity along a 43-mile stretch of the San Joaquin River about 50% of the time between 1988 and 1990;²⁰⁰ (3) 3-day and 12-day invertebrate toxicity events at two sampling locations within the Bay Delta Estuary in 1993 related to orchard insecticides;²⁰¹ (4) consistent invertebrate toxicity in the mid-1990's from insecticides in urban stormwater runoff that discharges directly to the Bay Delta Estuary from Central Valley and Bay Area Cities;²⁰² and (5) multiple diazinon toxicity events in the San Joaquin River at Vernalis, Sacramento Slough, and Orestimba Creek during January and February of 1996 and 1997.²⁰³ Algal toxicity was also observed as a result of herbicides in combination with elevated copper and zinc.²⁰⁴ More recent research documents toxic conditions for invertebrates caused by pyrethroid pesticides on a 30 km stretch of the American River, a

Water Quality Challenges in the San Francisco Bay/ Sacramento-San Joaquin Delta Estuary:

EPA's Action Plan



United States
Environmental Protection
Agency

August 2012

Water Quality Challenges in the San Francisco Bay/ Sacramento-San Joaquin Delta Estuary: EPA's Action Plan

Table of Contents

Executive Summary.....	1
Background.....	2
Clean Water Act Regulatory Assessment..	6
EPA's Action Plan.....	9
1 - Strengthen estuarine habitat protection standards	
2 - Advance regional water quality monitoring and assessment	
3 - Accelerate water quality restoration through Total Maximum Daily Loads	
4 - Strengthen selenium water quality criteria	
5 - Prevent pesticide pollution	
6 - Restore aquatic habitats while managing methylmercury	
7 - Support the Bay Delta Conservation Plan	
Appendix I - Staff Report: analysis of water quality issues in EPA's February 2011 ANPR	
Appendix II - Synthesis of public comments in response to ANPR	
Appendix III - Unabridged Advance Notice of Proposed Rulemaking, February 2011	

Appendix I

Staff Report: Analysis of Water Quality Issues in EPA's February 2011 ANPR

All Bay Delta Estuary waters are impaired by one or more contaminant. Aquatic uses are further adversely affected by a lack of adequate habitat. Discussed below are those water quality stressors which the U.S. Environmental Protection Agency (EPA or the Agency) believes are most significant, individually and/or cumulatively, for aquatic species health in the Estuary, including:

- **Selenium** (*page 2*)
- **Ammonia** (*page 6*)
- **Pesticides** (*page 9*)
- **Contaminants of Emerging Concern** (*page 17*)
- **Declining Estuarine Habitat** (*page 20*)
- **Fragmented Fish Migration Corridors** (*page 26*)
- **Loss of Wetlands, Floodplains and Riparian Corridors** (*page 29*)

These seven issues were discussed in detail in EPA's February 2011 Advance Notice of Proposed Rulemaking (ANPR).¹ In this appendix, for each issue, we include:

- a short statement of the problem and the current regulatory response (a more detailed discussion is in the ANPR, which is included for reference as Appendix III);
- highlights of the input received from the public in response to the ANPR (Appendix II is a full synthesis of public comment); and
- EPA's assessment of the adequacy of the regulatory response and staff recommendations for additional actions. In certain cases, EPA is not able to commit to implement the staff recommendation and this is stated.

The recommended actions include those EPA can take directly using the Agency's existing statutory authorities. Also included are recommended actions the State of California might take under the delegated federal Clean Water Act (CWA) program and/or their state authorities. EPA has attempted to be as specific as possible about actions needed to improve the Estuary's water quality so that it will better support aquatic species. At the same time, EPA recognizes that the next twenty years will be a period of significant change in the Bay Delta Estuary. Accordingly, EPA intends to evaluate the progress on these recommended actions in light of the evolving understanding of aquatic resource protection in the Bay Delta Estuary, so that Agency activities are always targeted to the most critical needs.

Collectively, these actions will contribute to the restoration of the Bay Delta Estuary. Even if they are all successfully implemented, however, they are not sufficient to resolve the multifaceted problems that have stressed the ecosystem to the point of collapse. These actions must be accompanied by progress on many other related fronts.

A. Selenium

1. The Problem

Selenium is a naturally occurring element that, when mobilized in the environment and transformed to organic, bioavailable forms, can be highly bioaccumulative under certain ecological conditions. Selenium in the diet, even in very small amounts, can produce birth defects and limit reproductive success in sensitive fish and wildlife. Selenium may also biomagnify and affect predators at the top of the foodweb. The main controllable sources of selenium in the Bay Delta Estuary are agricultural drainage (generated by irrigation of seleniferous soils in the western side of the San Joaquin Basin) and discharges from North Bay refineries (which process selenium-rich crude oil from the southern San Joaquin Basin).

2. Program Response

Selenium sources in both the San Joaquin Basin and in the North Bay are regulated under permits. In the San Joaquin Basin, three related Total Maximum Daily Loads (TMDLs) are being implemented in the Grasslands Bypass Project (GBP).² Operating under Waste Discharge Requirements issued by the Central Valley Regional Water Quality Control Board (Central Valley RWQCB) pursuant to California water quality law, the GBP is the key effort to date to control selenium discharges to the San Joaquin River. The drainage and water districts participating in the GBP have reduced selenium loads to the point that dischargers are now in compliance with existing selenium standards in the San Joaquin River between the Merced River confluence downstream to the South Delta confluence.³ However, water quality standards are not being met in the San Joaquin River reach upstream of the Merced confluence to Mud Slough and, according to U.S. Fish and Wildlife Service (USFWS), juvenile Chinook salmon (*Oncorhynchus tshawytscha*) in the entire San Joaquin River may still be at risk from the adverse effects of selenium at the levels currently permitted by the California Toxics Rule and Central Valley Region Basin Plan.⁴

North Bay refineries are regulated through federal CWA point source National Pollution Discharge Emission System (NPDES) permits. The permittees are conducting studies on the concentrations and speciation ambient levels of selenium as well as selenium in their effluent. Further reductions in selenium discharges to waterways may be needed to adequately protect selenium-sensitive species such as the salmon and the North American green sturgeon (*Acipenser medirostris*, a downstream resident of the Bay Delta Estuary). EPA anticipates that the San Francisco Bay Regional Water Quality Control Board (San Francisco Bay RWQCB) will consider this issue as it completes the North San Francisco Bay TMDL.

3. Public comments

Public comments generally acknowledged the importance of improving regulation of selenium by filling data and scientific gaps that currently limit our understanding of: (a) the forms of selenium entering the system, especially particulates that are readily bioavailable; and (b) loading and transport in the Bay Delta Estuary under varying hydrologies (particularly high flow periods which are likelier to transport particulates). They recognized the value of the United States Geological Survey (USGS) Presser-Luoma biodynamic model (discussed below),

provided the data used are up-to-date. Thus, there was support for more extensive monitoring. A number of parties suggested, or were open to considering, retiring of drainage impaired lands in the western San Joaquin Valley as one strategy for controlling selenium inputs to the aquatic environment.

4. Program Assessment and Recommendations

Our current understanding of ecosystem foodweb processes that concentrate selenium suggests that existing selenium water quality standards do not adequately protect aquatic species and wildlife in the Bay Delta. Existing standards are based on a water column value that does not reliably reflect the actual dietary exposure of species, as measured in tissue concentrations. Therefore, EPA has concluded that several additional actions are needed to better protect aquatic species in the Bay Delta Estuary:

a. In 2012, EPA Region 9⁵ will draft new site-specific numeric selenium criteria to protect aquatic species in the Bay Delta Estuary (aquatic life) and terrestrial species dependent upon the aquatic habitats of the Estuary. EPA is using an ecosystem-based model created by the USGS⁶ that reflects the food web in the Bay Delta Estuary, the diet of sensitive species, and their use of habitats and hydrological conditions. Formal public proposal of new criteria will follow scientific and agency reviews. The new criteria will likely decrease allowable concentrations of selenium in surface waters of the Bay Delta and set maximum selenium concentrations in the tissue of fish and wildlife.⁷

This is the first phase of revising selenium criteria statewide. For areas in California outside the Bay Delta Estuary, EPA Region 9 will support subsequent regulatory criteria development using the ecosystem-based methodology developed by the USGS, tailored to address threatened or endangered species in other watersheds.

b. At the national level, EPA is developing national “guidance” criteria for selenium to protect aquatic life in freshwater, based on methodology consistent with the USGS model. The national numeric criteria will be tailored to different hydrological conditions (flowing and standing waters), but may not account for the effects of selenium on threatened or endangered species. States and tribes can use these “guidance criteria” to regulate selenium, and/or EPA can use them to promulgate water quality standards on behalf of states and tribes.

c. EPA will support the San Francisco Bay RWQCB’s development and implementation of a TMDL for selenium in the North San Francisco Bay, Suisun Marsh and the West Delta (generally referred to as the North San Francisco Bay TMDL). EPA recommends that the TMDL use the site-specific criteria work under development by EPA, as described in “a” above. In January 2011, the San Francisco Bay RWQCB issued a report integrating the technical analyses completed to date. The January report acknowledges that there are significant data and assessment gaps, such as information on sources and distribution of particulate selenium, which is the form more biologically available.⁸ Implementation of this TMDL will focus on the major point sources (refineries) and the significant non-point loads (agriculture) entering from the Delta and its watershed. The discharge permits for the five Bay area refineries are due to be renewed within five years, at which time waste load allocations for selenium would

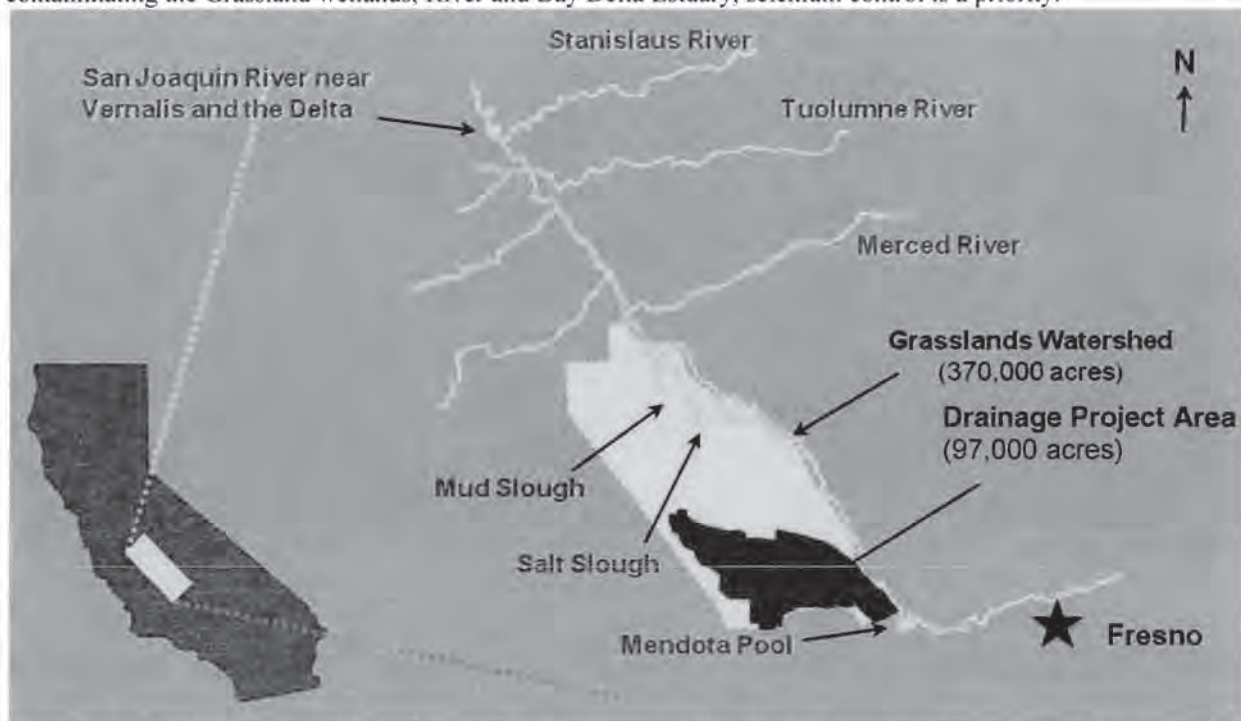
be reviewed. TMDL load allocations will address upstream sources coming into the Bay from the Delta.

d. EPA will continue to participate in the Grasslands Bypass Project through the Oversight Committee and its technical teams, including advising the Central Valley RWQCB on appropriate monitoring to include under the State Waste Discharge Requirement. The most significant controllable nonpoint source load of selenium to the Delta is agricultural activities in the San Joaquin Valley, where implementation of selenium TMDLs is under way through the GBP. *See box on page 5.* Although significant progress has been made, full compliance with water quality standards has taken longer than originally planned, and reaching the GBP goal of zero discharges of selenium by 2019 may require as-yet unproven treatment technologies or substantial reduction in irrigation.

e. EPA will review analysis generated as part of Bay Delta Conservation Plan (BDCP) to determine how changes in Delta conveyance and operations might affect selenium loads to the Estuary. The hydrologic and operational conditions under which selenium enters and moves through the Delta are important considerations. As the National Research Council (NRC) observed in their recent report, “infrastructure changes in the Delta such as construction of an isolated facility could result in the export of more Sacramento River water to the south, which would allow more Selenium-rich San Joaquin River water to enter the Bay.”⁹

Grasslands Bypass Project

The Grasslands Watershed encompasses 370,000 acres of intermingled wetlands and farms on the west side of California's San Joaquin Valley. Soils in this region are rich with selenium, a naturally occurring trace element that becomes toxic at high concentrations. With irrigation, selenium builds up in both surface water and shallow groundwater. In the Grasslands, as well as the larger Westlands Water District to the south, maintaining agricultural production often requires removing shallow ground water. However, selenium in this drainage water can put sensitive species at risk. This was dramatized when drainage water conveyed via the San Luis Drain from Westlands to a wetland area, Kesterson, caused deformities in migratory birds. The San Luis Drain was closed and Kesterson remediated. Unlike Westlands, which is now prohibited from exporting drainage to the San Joaquin watershed and Delta, runoff and agricultural drainage from the Grasslands watershed naturally enter the San Joaquin River. To avoid contaminating the Grassland wetlands, River and Bay Delta Estuary, selenium control is a priority.



In 1996, stakeholders established the Grasslands Bypass Project (GBP), which uses the San Luis Drain to divert selenium-laden agricultural drainage water away from sensitive wetlands while implementing a selenium reduction program to meet water quality standards within a specified period of time. Discharge into Mud Slough from the Drain is subject to Waste Discharge Requirements issued by the Central Valley RWQCB that are linked to three TMDLs for selenium. Unique features of the GBP include:

- Formation of a regional drainage entity to coordinate selenium reduction activities;
- Enforceable reduction targets for selenium loads and incentive fees directed towards selenium controls;
- A performance-based program that provides the irrigation districts and drainage district flexibility to determine how to best meet overall selenium reduction targets in a cost-effective manner; and
- A monitoring, assessment and reporting program supported by an interagency technical team.

Under the GBP, participating irrigation districts have reduced their discharges of selenium by up to 90% through on-site measures such as increasing irrigation efficiency and reusing irrigation water. Full compliance with water quality standards has taken longer than originally planned, and reaching the GBP goal of zero discharges of selenium by 2019 may require unproven treatment technologies or substantial reductions in irrigation. Even if water quality standards are met within a decade, as envisioned under the GBP, protecting water quality and sensitive species will require long-term management of selenium in the San Joaquin River basin. This introduces several questions that cut across science, policy, and management:

- ✓ The focus on controlling discharges of selenium to surface waters can encourage practices that “store” selenium elsewhere, e.g., groundwater. Will this accumulated selenium ultimately enter pathways that adversely affect sensitive species in the short- or long-term?
- ✓ How can technically and economically feasible means of reducing volumes of contaminated drainage water be promoted?
- ✓ What needs to be done now by agencies and the agricultural community to establish the institutional framework necessary for this perpetual challenge?



United States
Environmental Protection
Agency

http://water.epa.gov/drink/contaminants/basicinformation/disinfectionbyproducts.cfm#What%20are%20EPA%E2%80%99s%20drinking%20water%20regulations%20for%20disinfection%20byproducts

Water: Basic Information about Regulated Drinking Water Contaminants

You are here: [Water](#) » [Drinking Water](#) » [Drinking Water Contaminants](#) » [Basic Information about Regulated Drinking Water Contaminants](#) » [Basic Information about Disinfection Byproducts in Drinking Water: Total Trihalomethanes, Haloacetic Acids, Bromate, and Chlorite](#)

Basic Information about Disinfection Byproducts in Drinking Water: Total Trihalomethanes, Haloacetic Acids, Bromate, and Chlorite

To protect drinking water from disease-causing organisms, or pathogens, water suppliers often add a disinfectant, such as chlorine, to drinking water. However, disinfection practices can be complicated because certain microbial pathogens, such as *Cryptosporidium*, are highly resistant to traditional disinfection practices. Also, disinfectants themselves can react with naturally-occurring materials in the water to form byproducts, which may pose health risks.

A major challenge for water suppliers is how to control and limit the risks from pathogens and disinfection byproducts. It is important to provide protection from pathogens while simultaneously minimizing health risks to the population from disinfection byproducts. For more information, see fact sheets on [Pathogens and Indicators](#) and [Disinfectants](#).

- What disinfection byproducts does EPA regulate, how are they formed, and what are their health effects in drinking water at levels above the maximum contaminant level?
- What are EPA's drinking water regulations for disinfection byproducts?
- How will I know if disinfection byproducts are in my drinking water?
- How will disinfection byproducts be removed from my drinking water?
- How do I learn more about my drinking water?

What disinfection byproducts does EPA regulate, how are they formed, and what are their health effects in drinking water at levels above the maximum contaminant level?

Disinfection Byproduct (Chemical Abstract Service Registry Number)	How is it formed?	Health Effects
Total Trihalomethanes		
<i>Bromodichloromethane</i> (75-27-4)	Trihalomethanes occur when naturally-occurring organic and inorganic materials in the water react with the disinfectants, chlorine and chloramine.	Some people who drink water containing total trihalomethanes in excess of the MCL over many years could experience liver, kidney, or central nervous system problems and increased risk of cancer.
<i>Bromoform</i> (75-25-2)		
<i>Dibromochloromethane</i> (124-48-1)		
<i>Chloroform</i> (67-66-3)		
Haloacetic acids:		
<i>Dichloroacetic acid</i> (79-43-6)	Haloacetic acids occur when naturally-occurring organic and inorganic materials in the water react with the disinfectants, chlorine and chloramine.	Some people who drink water containing haloacetic acids in excess of the MCL over many years may have an increased risk of getting cancer.
<i>Trichloroacetic acid</i> (76-03-9)		
<i>Chloroacetic acid</i> (79-11-8)		
<i>Bromoacetic acid</i> (79-08-3)		
<i>Dibromoacetic acid</i> (631-64-1)		
Bromate (15541-45-4)	Bromate occurs when bromide in the water reacts with the disinfectant, ozone.	Some people who drink water containing bromate in excess of the MCL over many years may have an increased risk of getting cancer.
Chlorite (7758-19-2)	Chlorite occurs when chlorine dioxide breaks down.	Some infants and young children who drink water containing chlorite in excess of the MCL could experience nervous system effects. Similar effects may occur in fetuses of pregnant women who drink water containing chlorite in excess of the MCL. Some people may experience anemia.

This health effects language is not intended to catalog all possible health effects for disinfection byproducts. Rather, it is intended to inform consumers of some of the possible health effects associated with disinfection byproducts in drinking water when the rule was finalized.

What are EPA's drinking water regulations for disinfection byproducts?

In 1974, Congress passed the Safe Drinking Water Act. This law requires EPA to determine the level of contaminants in drinking water at which no adverse health effects are likely to occur. These non-enforceable health goals, based solely on possible health risks and exposure over a lifetime, with an adequate margin of safety, are called maximum contaminant level goals (MCLG). Contaminants are any physical, chemical, biological or radiological substances or matter in water. EPA sets MCLGs based on the best available science to prevent potential health problems.

Based on the MCLG, EPA sets an enforceable regulation called a maximum contaminant level (MCL). MCLs are set as close to the health goals as possible, considering cost, benefits and the ability of public water systems to detect and remove contaminants using suitable treatment technologies. MCLs for disinfection byproducts are set at the following levels:

Levels for Total Trihalomethanes

Disinfection Byproduct	MCLG	MCL
<i>Bromodichloromethane</i>	Zero	0.080 mg/L or 80 ppb
<i>Bromoform</i>	Zero	(Sum of the concentrations of all four trihalomethanes) as an annual average
<i>Dibromochloromethane</i>	0.06 mg/L or 60 ppb	
<i>Chloroform</i>	0.07 mg/L or 70 ppb	

Levels for Haloacetic acids

Disinfection Byproduct	MCLG	MCL
<i>Dichloroacetic acid</i>	Zero	0.060 mg/L or 60 ppb
<i>Trichloroacetic acid</i>	0.02 mg/L or 20 ppb	(Sum of the concentrations of all five haloacetic acids) as an annual average
<i>Monochloroacetic acid</i>	0.07 mg/L or 70 ppb	
<i>Bromoacetic acid</i>	Regulated with this group but has no MCLG	
<i>Dibromoacetic acid</i>	Regulated with this group but has no MCLG	
<i>Bromate</i>	Zero	0.010 mg/L or 10 ppb as an annual average
<i>Chlorite</i>	0.80 mg/L or 800 ppb	1.0 mg/L or 1 part per million (ppm)

MCLs are set as close to the health goals as possible, considering cost, benefits and the ability of public water systems to detect and remove contaminants using suitable treatment technologies. States may set more stringent drinking water MCLGs and MCLs for disinfection byproducts than EPA.

The following drinking water regulations apply to disinfectants and disinfection byproducts:

- [Stage 1 Disinfectants and Disinfection Byproducts Rule \(Stage 1 DBP\)](#) (December 16, 1998)
The Stage 1 Disinfectants and Disinfection Byproducts Rule reduces exposure to disinfection byproducts for customers of community water systems and non-transient non-community systems, including those serving fewer than 10,000 people, that add a disinfectant to the drinking water during any part of the treatment process.
- [Stage 2 Disinfectants and Disinfection Byproducts Rule \(Stage 2 DBP\)](#) (December 15, 2005)
Stage 2 DBP rule builds upon earlier rules that addressed disinfection byproducts to improve your drinking water quality and provide additional public health protection from disinfection byproducts.

The Safe Drinking Water Act requires EPA to periodically review the national primary drinking water regulation for each contaminant and revise the regulation, if appropriate, based on new scientific data. EPA will include the Disinfectants and Disinfection Byproducts rules in a future review cycle.

- [More information on the Six Year Review of Drinking Water Standards](#)

How will I know if disinfection byproducts are in my drinking water?

When routine monitoring indicates that disinfection byproduct levels are above the MCL, your water supplier must take steps to reduce the amount of disinfection byproducts so that they are below that level. Water suppliers must notify their customers as soon as practical, but no later than 30 days after the system learns of the violation. Additional actions, such as providing alternative drinking water supplies, may be required to prevent serious risks to public health.

- [See EPA's public notification requirements for public water systems.](#)

How will disinfection byproducts be removed from my drinking water?

Water systems that use surface water or ground water under the direct influence of surface water and use conventional filtration treatment are required to remove specified percentages of organic materials that may react with disinfectants to form disinfection byproducts, prior to disinfection. Other control strategies include modification of disinfection practices in a manner that still provides adequate protection against pathogens.

How do I learn more about my drinking water?

EPA strongly encourages people to learn more about their drinking water, and to support local efforts to protect the supply of safe drinking water and upgrade the community water system. Your water bill or telephone book's government listings are a good starting point for local information.

Contact your water utility. EPA requires all community water systems to prepare and deliver an annual consumer confidence report (CCR) (sometimes called a water quality report) for their customers by July 1 of each year. If your water provider is not a community water system, or if you have a private water supply, request a copy from a nearby community water system.

- [The CCR summarizes information regarding sources used \(i.e., rivers, lakes, reservoirs, or aquifers\), detected contaminants, compliance and educational information.](#)
- [Some water suppliers have posted their annual reports on EPA's website.](#)

Other EPA websites

You will need Adobe Reader to view some of the files in this section. See [EPA's PDF page](#) to learn more.

- Find an answer or ask a question about drinking water contaminants on [EPA's Question and Answer website](#) or call EPA's Safe Drinking Water Hotline at (800)

426-4791

- [EPA's Microbials and Disinfection Byproducts website](#)
 - [Stage 2 Disinfectant/Disinfection Byproducts Rule](#)
 - [Stage 1 Disinfectant/Disinfection Byproducts Rule](#)
- [EPA's Envirofacts ICR website](#)
 - [Disinfection Byproduct Information](#)
 - [Disinfection Byproducts: A Reference Resource](#)
 - [Disinfection Byproducts Health Effects](#)
- [EPA's Guidance Manual Alternative Disinfectants and Oxidants \(PDF\)](#) (41 pp, 385 K)
- [EPA's Integrated Risk Information System](#)
- [EPA History of Drinking Water Treatment \(PDF\)](#) (4 pp, 156 K)
- [EPA Drinking Water Treatment Fact Sheet \(PDF\)](#) (3 pp, 258 K)

Other Federal Departments and Agencies

- **Bromate**
 - [Centers for Disease & Prevention Control's National Institute for Occupational Safety and Health International Chemical Safety Card for Sodium Bromate](#)
- **Chlorite**
 - [Agency for Toxic Substances and Disease Registry, ToxFAQs, Chlorine Dioxide and Chlorite](#)
 - [Agency for Toxic Substances and Disease Registry, Toxicological Profile, Chlorine Dioxide and Chlorite](#)

Last updated on Friday, December 13, 2013



Integrated Risk Information System

You are here: [EPA Home](#) [Research](#) [Environmental Assessment](#) [IRIS](#) [IRIS Summaries](#)

Bromate (CASRN 15541-45-4)

[view QuickView](#)

[MAIN CONTENTS](#)

Search IRIS by Keyword

☒ List of IRIS Substances
 ☐ SSu aries o icological eviews
 ☐ Entire S Website

Reference Dose for Chronic Oral Exposure (RfD)

You will need Adobe Reader to view some of the files on this page. See [EPA's PDF page](#) to learn more.

Note: A TOXICOLOGICAL REVIEW is available for this chemical in Adobe PDF Format (58 Pages, 261 Kbytes). Similar documents can be found in the List of Available IRIS Toxicological Reviews.

Links to specific pages in the toxicological review are available throughout this summary. To utilize this feature, your Web browser and Adobe program must be configured properly so the PDF displays within the browser window. If your browser and Adobe program need configuration, please go to EPA's PDF page for instructions.

1002

Bromate; CASRN 15541-45-4 (06/06/2001)

Human health assessment information on a chemical substance is included in the IRIS database only after a comprehensive review of toxicity data, as outlined in the [IRIS assessment development process](#). Sections I (Health Hazard Assessments for Noncarcinogenic Effects) and II (Carcinogenicity Assessment for Lifetime Exposure) present the conclusions that were reached during the assessment development process. Supporting information and explanations of the methods used to derive the values given in IRIS are provided in the [guidance documents located on the IRIS website](#).

STATUS OF DATA FOR Bromate

File First On-Line 06/06/2001

Category (section)	Status	Last Revised
Oral RfD Assessment (I.A.)	on-line	06/06/2001*
Inhalation RfC Assessment (I.B.)	not available	06/06/2001*
Carcinogenicity Assessment (II.)	on-line	06/06/2001*

*A comprehensive review of toxicological studies was completed (July 17, 2006) - please see sections I.A.6., I.B.6., and II.D.2. for more information.

I. Chronic Health Hazard Assessments for Noncarcinogenic Effects

I.A. Reference Dose for Chronic Oral Exposure (RfD)

Substance Name — Bromate
 CASRN — 15541-45-4
 Last Revised — 06/06/2001

The oral Reference Dose (RfD) is based on the assumption that thresholds exist for certain toxic effects such as cellular necrosis. It is expressed in units of mg/kg-day. In general, the RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. Please refer to the Background Document for an elaboration of these concepts. RfDs can also be derived for the noncarcinogenic health effects of substances that are also carcinogens. Therefore, it is essential to refer to other sources of information concerning the carcinogenicity of this substance. If the U.S. EPA has evaluated this substance for potential human carcinogenicity, a summary of that evaluation will be contained in Section II of this file.

___I.A.1. Oral RfD Summary

Critical Effect	Experimental Doses*	UF	MF	RfD
		300	1	4E-3 mg BrO ₃ ⁻ /kg-day
Renal effects: Urothelial hyperplasia	NOAEL: 1.5 Mg KBrO ₃ /kg-day (1.1 mg BrO ₃ ⁻ /kg-day)			
Rat feeding study	LOAEL: 7.9 mg KBrO ₃ /kg-day (6.1 mg BrO ₃ ⁻ /kg-day)			
DeAngelo et al. (1998)				

*Conversion Factors and Assumptions — Doses of potassium bromate were calculated by DeAngelo et al. (1998) on the basis of measured water consumption, body weight, and water concentrations. Potassium bromate doses were converted to bromate ion doses by multiplying by 0.766, the ratio of molecular weights for bromate ion (127.9) and potassium bromate (167).

___I.A.2. Principal and Supporting Studies (Oral RfD)

DeAngelo, AB; George, MH; Kilburn, SR; et al. (1998) Carcinogenicity of potassium bromate administered in the drinking water to male B6C3F1 mice and F344/N rats. Toxicol Pathol 26(5):587-594.

DeAngelo et al. (1998) administered potassium bromate in drinking water at concentrations of 0, 0.02, 0.1, 0.2, and 0.4 g/L and of 0, 0.08, 0.4, and 0.8 g/L to male F344 rats and male B6C3F1 mice (78/group), respectively, for 100 weeks. Time-weighted mean daily doses were calculated by the authors from the mean daily water consumption and the measured concentrations of potassium bromate. Bromate doses for the rats were 0, 1.1, 6.1, 12.9, and 28.7 mg BrO₃⁻/kg-day. For rats, 6 animals/group were included for interim sacrifices, which occurred at 12, 26, 52, and 77 weeks. Parameters evaluated included survival, body weight, organ weight, serum chemistry, and histopathology.

In male rats, survival in the 28.7 mg BrO₃⁻/kg-day dose group was decreased compared with controls beginning by approximately week 79 (Wolf, 1998a); this decrease was statistically significant by study termination. In the 12.9 mg BrO₃⁻/kg-day dose group, survival was decreased compared with controls beginning by approximately week 88 (Wolf, 1998a); this decrease was also significant by study termination. Male rats in the 28.7 mg BrO₃⁻/kg-day dose group also had a statistically significant decrease (18%) in the final mean body weight compared with controls. The

decrease in survival and body weight was attributed to an excessive mesothelioma burden (Wolf, 1998a). The effects of potassium bromate on survival and body weight in rats indicate that the maximum tolerated dose (MTD) was reached in this study.

In rats, water consumption was statistically significantly increased in the 12.9 and 28.7 mg/kg-day dose groups; the dose-related trend was also statistically significant. Rats in the 12.9 mg/kg-day dose group had increases, not statistically significant, in absolute and relative kidney weight and relative spleen weight. Rats in the 28.7 mg/kg-day dose group had statistically significant increases in relative liver weight, absolute and relative kidney weight, absolute and relative thyroid weight, and relative spleen weight. Nonneoplastic kidney lesions were observed in rats. Although the severity of chronic nephropathy was comparable between control and treated rats, there was a significant dose-dependent increase in the incidence of urothelial hyperplasia in rats in dose groups of 6.1 mg/kg-day and higher. The authors also observed foci of mineralization of the renal papilla and eosinophilic droplets in the proximal tubule epithelium, although no information on the dose levels for these findings was presented. No other treatment-related nonneoplastic effects were observed in any other tissue examined. On the basis of kidney effects in male rats, this study identifies a NOAEL of 1.1 mg BrO₃⁻/kg-day and a LOAEL of 6.1 mg BrO₃⁻/kg-day.

Results of DeAngelo et al. (1998) in male B6C3F1 mice indicate that mice may be less sensitive than rats to the effects of bromate exposure. Time-weighted mean daily doses were calculated by the authors from the mean daily water consumption and the measured concentrations of potassium bromate. Bromate doses for mice were 0, 6.9, 32.5, and 59.6 mg BrO₃⁻/kg-day. For mice, 7 animals/group were included for interim sacrifice, which occurred at 14, 31, 53, and 78 weeks. Bromate in drinking water had no effect on the survival, body weight, or organ weight of male mice. Water consumption was decreased by 17% in the 59.6 mg BrO₃⁻/kg-day dose group; this decrease was statistically significantly different from controls. Serum chemistry results were comparable between controls and treated mice, and no increased incidence of nonneoplastic lesion occurred in any tissue examined. Therefore, the highest dose tested, 59.6 mg BrO₃⁻/kg-day, is a freestanding NOAEL in mice.

___ I.A.3. Uncertainty and Modifying Factors (Oral RfD)

UF = 300.

An uncertainty factor (UF) of 10 is applied to account for extrapolating from animals to humans and another factor of 10 is used to protect sensitive subpopulations and to account for potential differences between adults and children. A factor of 3 is used to account for some deficiencies in the database. The bromate database consists of chronic and subchronic studies in rats and mice and a screening-level reproductive/developmental study in rats. The database is missing developmental studies in two species and a multigeneration study. This results in a total uncertainty factor of 300.

MF = 1.

___ I.A.4. Additional Studies/Comments (Oral RfD)

Several cases of acute bromate intoxication have been reported in humans following accidental or suicidal ingestion of permanent hair wave neutralizing solutions (Benson, 1951; Parker and Barr, 1951; Quick et al., 1975; Gradus et al., 1984; Warshaw et al., 1985; Lue et al., 1988; Mack, 1988; Matsumoto et al., 1980; Lichtenberg et al., 1989; Watanabe et al., 1992). These products usually contain either 2% potassium bromate or 10% sodium bromate. The most common acute signs are severe gastrointestinal irritation (vomiting, pain, diarrhea) and the Central Nervous System depression (lethargy, hypotension, hypotonicity, loss of reflexes). Anemia from intravascular hemolysis may also occur. These effects are usually reversible. Later sequelae (usually within several days) include marked renal injury and hearing loss. Death from renal failure may ensue if

medical intervention is not successful. If support is successful, renal function generally returns after 5-10 days. Hearing loss is usually irreversible. Estimated doses in these cases ranged from about 20 to 1,000 mg BrO_3^-/kg .

Nakano et al. (1989) exposed male Wistar rats to 0.04% potassium bromate in drinking water for up to 15 months. If an intake of 0.1 L/kg-day is assumed, this corresponds to a dose of about 30 mg $\text{BrO}_3^-/\text{kg-day}$. Body weight gain was markedly inhibited in the exposed animals. Histological examination of kidneys at 7-11 weeks revealed karyopyknotic foci in tubules of the inner medulla. Increased blood urea nitrogen (BUN), along with marked structural abnormalities of the cortical tubules, was noted after 15 months. Based on the decreased body weight gain and renal effects, this study identified a LOAEL of 30 mg $\text{BrO}_3^-/\text{kg-day}$, but did not identify a NOAEL.

Kurokawa et al. (1983) investigated the carcinogenicity of potassium bromate in the drinking water of F344 rats. Potassium bromate was administered to F344 rats (53/sex/group) at concentrations of 0, 250, and 500 ppm for 110 weeks. (Equivalent doses of bromate ion were approximately 12 and 33 mg bromate/kg-day, estimated from average reported body weights and water consumption.) However, the growth of males in the high-dose group was severely inhibited, so the concentration was reduced to 400 ppm at week 60. Body weights were recorded weekly. At autopsy, blood was collected for hematological analysis. Organs were collected, weighed, and evaluated histopathologically. Body weight gain was significantly reduced in high-dose males, but not in the other treated groups. Survival was reduced in high-dose males by about week 60 and in low-dose males by about week 100. No effect on survival was observed in treated female rats. A variety of noncancer effects was reported, including degenerative, necrotic, and regenerative changes in renal tubules; formation of hyaline droplets; thickening of transitional epithelium of renal pelvis, papillary hyperplasia, and papillary growth. The authors noted that the lesions were more extensive in degree and distribution in treated rats compared with controls, especially males. However, no information is provided on the incidence of these lesions or on the statistical significance of these findings; therefore, a NOAEL for noncancer effects cannot be determined.

In a chronic study of bromate carcinogenicity, Kurokawa et al. (1986a) treated groups of 20-24 male F344 rats with water containing potassium bromate at 0, 15, 30, 60, 125, 250, or 500 mg/L for 104 weeks. The average doses in Kurokawa et al. (1986a) for male rats were 0, 0.7, 1.3, 2.5, 5.6, 12.3, and 33 mg $\text{BrO}_3^-/\text{kg-day}$. The weights of selected organs and all tumors were recorded. Histological examination of tissues only involved counting of neoplastic lesions. Compared with controls, the males in the high-dose group had decreased body weight gain and decreased survival, beginning at approximately week 70. Survival and body weight gain were comparable with controls for all remaining dose groups. The only nonneoplastic effect noted by the authors was a dose-related enhancement of the severity of nephropathic changes; however, no information was given regarding the doses at which these changes were observed.

Kurokawa et al. (1986b) studied the carcinogenic potential of potassium bromate in both male and female F344 rats and female B6C3F1 mice. Potassium bromate in drinking water was administered to the animals. Time-weighted mean doses of potassium bromate were estimated by the authors based on measured water consumption and body weight. The average bromate doses for rats were 0, 9.6, and 21.3 mg $\text{BrO}_3^-/\text{kg-day}$ in males and 0, 9.6, and 19.6 mg $\text{BrO}_3^-/\text{kg-day}$ in females. The average bromate doses for mice were 0, 43.5, and 91.6 mg $\text{BrO}_3^-/\text{kg-day}$. Parameters evaluated include body and organ weight, hematology, serum chemistry, and histopathology. Compared with controls, male rats in the high-dose group had a marked decrease in body weight gain and a decrease in survival, beginning at approximately week 70. The authors did not describe the cause of the decreased survival and body weight. For the low-dose groups in male rats and all dose groups in female rats and mice, survival and body weight gain were comparable to controls. Several non-neoplastic effects were described by the authors. Significant decreases in serum chemistry, including glutamate pyruvate transaminase (GPT), albumin-to-globulin ratio, potassium, and cholinesterase were observed in female rats in the high-dose group. Also, slightly increased BUN

was observed in both male and female rats; dose groups were not specified. Degenerative and necrotic kidney lesions were observed in treated rats. Specific findings included hyaline casts in the tubular lumen, hyaline droplets, eosinophilic bodies, and brown pigments in the tubular epithelium. Again, however, the doses at which these changes were observed were not specified. No nonneoplastic changes in bromate-treated mice were discussed by the authors.

The subchronic effects of bromate were evaluated in Kurokawa et al. (1990). Potassium bromate in water at concentrations of 0, 150, 300, 600, 1,250, 2,500, 5,000 or 10,000 ppm was administered to groups of F344 rats (10/sex/group) for 13 weeks. Daily doses corresponding to these concentrations are about 0, 16, 32, 63, 140, 270, 650, or 1,080 mg BrO₃⁻/kg. All animals exposed to >1,250 ppm died within 7 weeks. Observed signs of toxicity included significant inhibition of body weight gain in males at 600 ppm and above and significant increases of serum parameters (glutamate oxaloacetate transaminase, glutamate pyruvate transaminase, lactate dehydrogenase, ALP, BUN, Na⁺, cholinesterase) in both sexes at 600 ppm. Serum potassium levels were significantly decreased. Droplets of various sizes and regenerative changes in the renal tubules were observed. This study identifies 63 mg/kg as an adverse effect level, but insufficient data were provided to determine whether effects occurred at lower doses.

In a study conducted for the National Toxicology Program, Wolf and Kaiser (1996) evaluated the potential reproductive and developmental toxicity of sodium bromate in Sprague-Dawley rats following oral administration in drinking water at concentrations of 0.25 ppm (2.6 mg/kg-day), 80 ppm (9.0 mg/kg-day), or 250 ppm (25.6 mg/kg-day) over a 35-day period. (Equivalent bromate ion doses are 2.2, 7.7, and 22.0 mg BrO₃⁻/kg-day.) Two groups of female rats were treated. The first group (10/dose group) was dosed from study days 1-34 to test for effects during conception and early gestation. The second group (13/dose group) was dosed from gestation day 6 to postnatal day 1 to test for effects during late gestation and birth. Male rats (10/group) were cohabitated with the second group for 5 days before dosing (study days 1-5) and were dosed from study day 6 to day 34/35. Endpoints evaluated in males included clinical pathology, organ weight, sperm analysis, and histopathology. Endpoints evaluated in females included maternal body weight, number and weight of pups, and number of uterine implantations. Treated males in the 250-ppm dose group demonstrated a statistically significant decrease (18%) in epididymal sperm density. All other endpoints evaluated were comparable between controls and treated groups. Female reproductive function was not adversely affected. No treatment-related gross or microscopic changes occurred in the kidney, liver, spleen, testis, or epididymis. These results indicate that sodium bromate treatment does not produce any adverse signs of general toxicity at any of the dose levels tested, and on the basis of these findings, a MTD was not reached. This study identifies a NOAEL of 80 ppm (7.7 mg BrO₃⁻/kg-day) and a LOAEL of 250 ppm (22.0 mg BrO₃⁻/kg-day) on the basis of changes in sperm density.

For more detail on Susceptible Populations, exit to [the toxicological review, Section 4.7 \(PDF\)](#).

___ I.A.5. Confidence in the Oral RfD

Study — High
Database — Medium
RfD — Medium

The overall confidence in this RfD assessment is medium. Confidence in the principal study is high because the study was well conducted, used adequate numbers of animals, and evaluated appropriate endpoints. Confidence in the database is medium. Although the database contains several subchronic and chronic studies of bromate, only one study provides adequate dose-response information regarding renal effects of bromate. A screening-level reproductive/developmental study suggests bromate may be a male reproductive toxicant; this effect needs to be more completely

characterized. In addition, the database is missing a reproductive/developmental study for a second species and a multigeneration study. Reflecting medium confidence in the database, the confidence in the RfD is medium.

For more detail on Characterization of Hazard and Dose Response, exit to the toxicological review, Section 6 (PDF)

___I.A.6. EPA Documentation and Review of the Oral RfD

Source Document: -- U.S. EPA, 2001

This assessment was peer reviewed by external scientists. Their comments have been evaluated carefully and incorporated in finalization of this IRIS Summary. A record of these comments is included in Appendix A of the source. ***To review this appendix, exit to the toxicological review, Appendix A, Summary of and Response to External Peer Review Comments (PDF).***

Other EPA Documentation — None

Agency Consensus Date 5/22/01

A comprehensive review of toxicological studies published through July 2006 was conducted. No new health effects data were identified that would be directly useful in the revision of the existing RfD for Bromate and a change in the RfD is not warranted at this time. For more information, IRIS users may contact the IRIS Hotline at hotline.iris@epa.gov or 202-566-1676.

___I.A.7. EPA Contacts (Oral RfD)

Please contact the IRIS Hotline for all questions concerning this assessment or IRIS, in general, at (202)566-1676 (phone), (202)566-1749 (FAX), or hotline.iris@epa.gov (Internet address).

__I.B. Reference Concentration for Chronic Inhalation Exposure (RfC)

Substance Name — Bromate

CASRN — 15541-45-4

Last Revised — 06/06/2001

The inhalation Reference Concentration (RfC) is analogous to the oral RfD and is likewise based on the assumption that thresholds exist for certain toxic effects such as cellular necrosis. The inhalation RfC considers toxic effects for both the respiratory system (portal-of-entry) and for effects peripheral to the respiratory system (extrarespiratory effects). It is generally expressed in units of mg/cu.m. In general, the RfC is an estimate (with an uncertainty spanning perhaps an order of magnitude) of a daily inhalation exposure of the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. Inhalation RfCs were derived according to the Interim Methods for Development of Inhalation Reference Doses (EPA/600/8-88/066F, August 1989) and, subsequently, according to Methods for Derivation of Inhalation Reference Concentrations and Application of Inhalation Dosimetry (EPA/600/8-90/066F, October 1994). RfCs can also be derived for the noncarcinogenic health effects of substances that are carcinogens. Therefore, it is essential to refer to other sources of information concerning the carcinogenicity of this substance. If the U.S. EPA has evaluated this substance for potential human carcinogenicity, a summary of that evaluation will be contained in Section II of this file.

___I.B.1. Inhalation RfC Summary

Currently, no data are available to derive an RfC for bromate. No data are available to predict the effect of inhaled bromate on the respiratory tract; therefore, it would not be appropriate to derive an RfC for bromate on the basis of oral data.

___ I.B.2. Principal and Supporting Studies (Inhalation RfC)

None.

___ I.B.3. Uncertainty and Modifying Factors (Inhalation RfC)

None.

___ I.B.4. Additional Studies/Comments (Inhalation RfC)

None.

___ I.B.5. Confidence in the Inhalation RfC

None.

___ I.B.6. EPA Documentation and Review of the Inhalation RfC

Source Document - U.S. EPA, 2001

Other EPA Documentation — None

Agency Consensus Date 5/22/01

A comprehensive review of toxicological studies published through July 2006 indicated that there is insufficient health effects data to derive an RfC for Bromate at this time. For more information, IRIS users may contact the IRIS Hotline at hotline.iris@epa.gov or 202-566-1676.

___ I.B.7. EPA Contacts (Inhalation RfC)

Please contact the IRIS Hotline for all questions concerning this assessment or IRIS, in general, at (202)566-1676 (phone), (202)566-1749 (FAX), or hotline.iris@epa.gov (Internet address).

__ II. Carcinogenicity Assessment for Lifetime Exposure

Substance Name — Bromate

CASRN — 15541-45-4

Last Revised — 06/06/2001

Section II provides information on three aspects of the carcinogenic assessment for the substance in question, the weight-of-evidence judgment of the likelihood that the substance is a human carcinogen, and quantitative estimates of risk from oral exposure and from inhalation exposure. The quantitative risk estimates are presented in three ways. The slope factor is the result of the application of a low-dose extrapolation procedure and is presented as the risk per (mg/kg)/day. The unit risk is the quantitative estimate in terms of either risk per g/L drinking water or risk per g/cu.m air breathed. The third form in which risk is presented is the concentration of the chemical in drinking water or air associated with cancer risks of 1 in 10,000, 1 in 100,000, or 1 in 1,000,000. The rationale and methods used to develop the carcinogenicity information in IRIS are described in The Risk Assessment Guidelines of 1986 (EPA/600/8-87/045) and in the IRIS background

document. IRIS summaries developed since the publication of EPA's more recent Proposed Guidelines for Carcinogen Risk Assessment also use these Guidelines where indicated (Federal Register 61(79):17960-18011, April 23, 1996). Users are referred to Section I of this IRIS file for information on long-term toxic effects other than carcinogenicity.

II.A. Evidence for Human Carcinogenicity

II.A.1. Weight-of-Evidence Characterization

Under the current *Guidelines for Carcinogen Risk Assessment* (U.S. EPA, 1986), bromate would be classified as B2, probable human carcinogen. Under the *Proposed Guidelines for Carcinogen Risk Assessment* (U.S. EPA, 1996), bromate should be evaluated as a likely human carcinogen by the oral route of exposure. Insufficient data are available to evaluate the human carcinogenic potential of bromate by the inhalation route.

Although no epidemiological studies or studies of long-term human exposure to bromate are available, bromate is carcinogenic to male and female rats following exposure in drinking water. Three key studies (Kurokawa et al., 1986a, 1986b; DeAngelo et al., 1998) demonstrate the carcinogenicity of bromate in rats. All studies were well conducted, with an appropriate route of exposure and adequate numbers of animals. Several aspects of these bioassay studies support the conclusion that bromate has the potential to be a human carcinogen. First, tumors were observed at multiple sites, including the kidney (adenomas and carcinomas), the thyroid (follicular cell adenomas and carcinomas), and the peritoneum (mesotheliomas). In DeAngelo et al. (1998) the mesotheliomas arose from the *tunica vaginalis testis* and spread throughout the peritoneal cavity on the serosal surfaces of many organs. Kurokawa et al. (1986a, 1986b) do not specify the origin of the peritoneal mesotheliomas observed. Whereas male rats had tumors at all three sites, only kidney tumors were observed in female rats. However, the kidney tumors in female rats developed in the absence of the significant toxicity observed in the male rats.

Second, a clear dose-response relationship existed in tumor incidence and in severity/progression of tumors. Kurokawa (1986a) observed a progression in severity from renal dysplastic foci, a preneoplastic lesion, through renal adenomas to renal carcinoma as the dose increased. Kurokawa et al. (1986b) observed dose-response relationships for kidney tumors in both male and female rats. Kurokawa (1986a) observed dose-response relationships for two other tumor types, mesotheliomas and thyroid follicular cell, in male rats. DeAngelo et al. (1998) observed dose-response relationships for all three tumor types in rats.

There is some concern that the high dose in each of these studies exceeded the MTD for male rats. However, in all three studies, the decrease in survival began to appear relatively late in the study: at approximately week 70 in the Kurokawa et al. (1986a, 1986b) studies and at approximately week 79 in the DeAngelo et al. (1998) study. Two studies reported the time of first tumor observation: In Kurokawa et al. (1986b), the first tumor of any type was observed at 14 weeks, and in DeAngelo et al. (1998), the first tumor of any type was observed at 26 weeks. Therefore, the male rats in these studies were surviving long enough to have developed tumors. In addition, in the DeAngelo et al. (1998) study, the decreased survival and body weight gain appeared to be caused by the heavy mesothelioma burden of the animals (Wolf, 1998a); the cause of decreased survival and body weight gain in the Kurokawa et al. (1986b) study is not apparent. The decreased survival for high-dose groups in these studies does not compromise these studies for use in risk assessment.

The evidence is too limited to give high confidence in a conclusion about any mode of carcinogenic action. Oxidative stress may play a role in the formation of kidney tumors, but the evidence is insufficient to establish lipid peroxidation and free-radical production as the key events responsible for the induction of kidney tumors. In addition, no data are currently available to suggest any mechanism for the production of thyroid tumors and mesotheliomas by bromate. Bromate is mutagenic in both rats and mice in vivo and in vitro assays; albeit, the testing has been limited to

the Ames assay and in vitro cytogenetics and bone marrow assays. Given the limited data on the possible mechanism of carcinogenic action for bromate, it is a reasonable assumption that the production of tumors in rats occurs by a mode of action that is relevant to humans. With the lack of human data, the uncertainty surrounding the mode of action, and the inconsistency between the rat and mouse results, the human relevance of the rat data relies on the assumption that rat data, in general, are relevant to humans. In the absence of a biologically based model, the assumption of low-dose linearity is considered to be a reasonable public health protective approach for estimating the potential risk for bromate because of the limited data on its mode of action and because of some evidence of mutagenicity.

For more detail on Characterization of Hazard and Dose Response, exit to [the toxicological review, Section 6 \(PDF\)](#).

For more detail on Susceptible Populations, exit to [the toxicological review, Section 4.7 \(PDF\)](#).

___II.A.2. Human Carcinogenicity Data

None.

___II.A.3. Animal Carcinogenicity Data

Sufficient. Oral exposure to bromate results in an increased incidence of renal tubular tumors in male and female rats and an increased incidence of mesotheliomas and thyroid follicular cell tumors in male rats. In a chronic study of bromate carcinogenicity, Kurokawa et al. (1986a) treated groups of 20-24 male F344 rats with water containing potassium bromate at 0, 15, 30, 60, 125, 250, or 500 mg/L for 104 weeks. The average doses in Kurokawa et al. (1986a) for male rats were 0, 0.7, 1.3, 2.5, 5.6, 12.3, or 33 mg BrO₃⁻/kg-day. The weights of selected organs and all tumors were recorded. Histological examination of tissues only involved counting of neoplastic lesions. Compared with controls, the males in the high-dose group had decreased body weight gain and decreased survival, beginning at approximately week 70. Survival and body weight gain were comparable with controls for all remaining dose groups. A statistically significantly increased incidence was observed for dysplastic foci at doses of 1.3 mg BrO₃⁻/kg-day and above (incidence is 0/19, 1/19, 5/20, 6/24, 12/24, 19/20, and 19/20 for the 0, 0.7, 1.3, 2.5, 5.6, 12.3, and 33 mg BrO₃⁻/kg-day dose groups, respectively), for kidney tumors at doses of 5.6 mg BrO₃⁻/kg-day dose group and above (incidence is 0/19, 0/19, 0/20, 1/24, 5/24, 5/20, and 9/20 for the 0, 0.7, 1.3, 2.5, 5.6, 12.3, and 33 mg BrO₃⁻/kg-day dose groups, respectively) and for the thyroid tumors (incidence is 0/19, 0/19, 0/20, 1/24, 0/24, 3/20, and 7/20 for the 0, 0.7, 1.3, 2.5, 5.6, 12.3, and 33 mg BrO₃⁻/kg-day dose groups, respectively) and mesotheliomas (incidence is 0/19, 0/19, 3/20, 4/24, 2/24, 3/20, and 15/20 for the 0, 0.7, 1.3, 2.5, 5.6, 12.3, and 33 mg BrO₃⁻/kg-day dose groups, respectively) in the high-dose group only.

Kurokawa et al. (1986b) studied the carcinogenic potential of potassium bromate in both male and female F344 rats and female B6C3F1 mice. Potassium bromate in drinking water was administered to the animals. Time-weighted mean doses of potassium bromate were estimated by the authors based on measured water consumption and body weight. The average bromate doses for rats were 0, 9.6, and 21.3 mg BrO₃⁻/kg-day in males and 0, 9.6, and 19.6 mg BrO₃⁻/kg-day in females. The average bromate doses for mice were 0, 43.5, and 91.6 mg BrO₃⁻/kg-day. Parameters evaluated include body and organ weight, hematology, serum chemistry, and histopathology. Compared with controls, male rats in the high-dose group had a marked decrease in body weight gain and a decrease in survival beginning at approximately week 70. The authors did not describe the cause of the decreased survival and body weight. For the low-dose groups in male rats and all dose groups in female rats and mice, survival and body weight gain were comparable to controls. Treatment-

related, statistically significant tumors observed in rats included renal cell adenomas and carcinomas and peritoneal mesotheliomas (in males only). The incidence of kidney tumors was 3/53, 32/53, and 46/53 in male rats and 0/47, 28/50, and 39/49 in female rats for the control, low-dose, and high-dose groups, respectively. The incidence of mesotheliomas in male rats was 6/53, 17/52, and 28/46 for the control, low-dose, and high-dose groups, respectively. The authors note that a "high incidence" of tumors was observed in the thyroid; however, this incidence was not statistically significant. In male rats, the earliest renal tumor was observed at 14 weeks and the earliest mesothelioma was observed at 72 weeks. In female rats, the earliest renal tumor was observed at 85 weeks. In female mice, no significant differences in tumor incidence between exposed and control animals were apparent after 78 weeks of dosing, based on histological examination of tissues at week 104. The authors concluded that potassium bromate was carcinogenic in rats of both sexes, but not in mice.

DeAngelo et al. (1998) administered potassium bromate in drinking water at concentrations of 0, 0.02, 0.1, 0.2, and 0.4 g/L and of 0, 0.08, 0.4, and 0.8 g/L to male F344 rats and male B6C3F1 mice (78/group), respectively, for 100 weeks. Time-weighted mean daily doses were calculated by the authors from the mean daily water consumption and the measured concentrations of potassium bromate. Bromate doses for the rats were 0, 1.1, 6.1, 12.9, and 28.7 mg BrO₃⁻/kg-day. For rats, 6 animals/group were included for interim sacrifices, which occurred at 12, 26, 52, and 77 weeks. Parameters evaluated included survival, body weight, organ weight, serum chemistry, and histopathology.

In male rats, survival in the 28.7 mg BrO₃⁻/kg-day dose group was decreased compared with controls beginning by approximately week 79 (Wolf, 1998a); this decrease was statistically significant by study termination. In the 12.9 mg BrO₃⁻/kg-day dose group, survival was decreased compared with controls beginning by approximately week 88 (Wolf, 1998a); this decrease was also significant by study termination. Male rats in the 28.7 mg BrO₃⁻/kg-day dose group also had a statistically significant decrease (18%) in the final mean body weight compared with controls. The decrease in survival and body weight was attributed to an excessive mesothelioma burden (Wolf, 1998a). The effects of potassium bromate on survival and body weight in rats indicate that the MTD was reached in this study.

Tumor incidence for the terminal sacrifice in DeAngelo et al. (1998) is presented in Table 4. Statistically significant, dose-dependent increased tumor incidence was observed in the kidney (incidence of adenomas and carcinomas combined is 1/45, 1/43, 6/47, 3/39, and 12/32 for the 0, 1.1, 6.1, 12.9, and 28.7 mg BrO₃⁻/kg-day dose groups, respectively), thyroid (incidence of adenomas and carcinomas combined is 0/36, 4/39, 1/43, 4/35, and 14/30 for the 0, 1.1, 6.1, 12.9, and 28.7 mg BrO₃⁻/kg-day dose groups, respectively), and *tunica vaginalis testis* (incidence of mesotheliomas is 0/47, 4/49, 5/49, 10/47, and 27/43 for the 0, 1.1, 6.1, 12.9, and 28.7 mg BrO₃⁻/kg-day dose groups, respectively). Based on data from the National Toxicology Program historical controls database (NTP, 1998), the historical control rates for these tumor types in male F344 rats are 0.6% for kidney renal tubule adenomas and carcinomas, 2.1% for thyroid follicular cell adenomas and carcinomas, and 1.5% for mesotheliomas. The earliest renal tumors and mesotheliomas in DeAngelo et al. (1998) were observed at 52 weeks; the thyroid tumors were first seen at 26 weeks.

Results of DeAngelo et al. (1998) in male B6C3F1 mice indicate that mice may be less sensitive than rats to the effects of bromate exposure. Time-weighted mean daily doses were calculated by the authors from the mean daily water consumption and the measured concentrations of potassium bromate. Bromate doses for mice were 0, 6.9, 32.5, and 59.6 mg BrO₃⁻/kg-day. For mice, 7 animals/group were included for interim sacrifice, which occurred at 14, 31, 53, and 78 weeks. Bromate in drinking water had no effect on the survival, body weight, or organ weight of male mice. Water consumption was decreased by 17% in the 59.6 mg BrO₃⁻/kg-day dose group; this decrease was statistically significantly different from controls. The only type of tumor reported for male mice

was kidney tumors; however, the incidence of adenoma and carcinoma combined was not dose dependent. Tumor incidence at terminal sacrifice for combined kidney tumors in male mice was 0/40, 5/38 ($p < 0.05$; 3 carcinomas), 3/41 (1 carcinoma), and 1/44 for the 0, 6.9, 32.5, and 59.6 mg $\text{BrO}_3^-/\text{kg-day}$ groups, respectively.

Kurokawa et al. (1983) investigated the carcinogenicity of potassium bromate in the drinking water of F344 rats. Potassium bromate was administered to F344 rats (53/sex/group) at concentrations of 0, 250, and 500 ppm for 110 weeks. (Equivalent doses of bromate ion were approximately 12 and 33 mg bromate/kg-day, estimated from average reported body weights and water consumption.) However, the growth of males in the high-dose group was severely inhibited, so the concentration was reduced to 400 ppm at week 60. Body weights were recorded weekly. At autopsy, blood was collected for hematological analysis. Organs were collected, weighed, and evaluated histopathologically. Body weight gain was significantly reduced in high-dose males, but not in the other treated groups. Survival was reduced in high-dose males by about week 60 and in low-dose males by about week 100. No effect on survival was observed in treated female rats. The first tumor was observed at 14 weeks in males and at 58 weeks in females. Therefore, animals surviving beyond these times were included in the analysis. Incidences of several tumor types were elevated in a dose-dependent manner (although not statistically significant) in treated rats, including thyroid (male and female), adrenal gland (male), large intestine (male and female), liver (male), and spleen (male). In male rats, the incidence of renal cell tumors (both adenocarcinomas and adenomas) and peritoneal mesotheliomas were statistically significantly increased in both dose groups compared with controls. In female rats, the incidence of renal cell tumors (both adenomas and adenocarcinomas) was statistically significantly increased in both treated groups compared with controls.

___II.A.4. Supporting Data for Carcinogenicity

Matsushima et al. (1986) investigated the carcinogenicity of KBrO_3 administered subcutaneously to newborn rats and mice. One group of male and female newborn F344 rats and ICR mice (24 hours old) were given single subcutaneous injections of 9.6, 19, 38, 77, or 154 mg BrO_3^-/kg . Another group of newborn rats and mice received four weekly injections of 9.6, 19, 38, 77, or 154 mg BrO_3^-/kg until weaning. Control animals received injections of olive oil. Rats were sacrificed at 82 weeks, mice were sacrificed at 78 weeks, and organs were examined histologically. No significant differences in the incidence of tumors in male or female rats or mice were observed. Under the conditions of the study, potassium bromate had no potential for carcinogenicity in newborn male or female rats or mice.

Kurata et al. (1992) tested the tumor initiation potential of bromate in a 104-week study in which male F344/NCr rats (29 or 39/group) were given an intragastric dose of 300 mg/kg KBrO_3 (231 mg/kg BrO_3^-), the maximum tolerated single dose. The rats were administered bromate alone, bromate followed by 4,000 ppm sodium barbital in the animal diet as a promoter, or sodium barbital alone in the diet. Sodium barbital was added to the diet starting 2 weeks after the animals were dosed with potassium bromate. Rats were examined at 30, 52, and 104 weeks for nephropathy. At 30 weeks, renal damage (dysplastic tubular foci) was evident in the rats exposed to potassium bromate followed by sodium barbital and in rats exposed to sodium barbital, but not in those exposed to potassium bromate alone. The results indicated that a single oral dose of 300 mg/kg KBrO_3 (231 mg/kg BrO_3^-) administered to rats does not initiate renal tumors within a 104-week observation period.

Kurokawa et al. (1987) supplied groups of 8, 14, 20, and 26 male F344 rats with water containing 500 mg BrO_3^-/L for up to 104 weeks to assess the time course of renal cell tumor induction. The average daily consumption of potassium bromate was 41.9 mg/kg (32.3 mg BrO_3^-/kg). At 104 weeks, the surviving animals were sacrificed and examined histopathologically for dysplastic foci, renal adenomas and adenocarcinomas, thyroid follicular cell tumors and peritoneal mesotheliomas.

The occurrence of all tumors was significantly increased as treatment continued. Dysplastic foci and renal adenomas were first observed following 26 weeks of continuous treatment. Renal dysplastic foci and adenomas were each significantly increased over controls by 52 weeks of treatment (mean number of renal cell tumors per rat was 0.81, vs. 0 in the controls). Continuous potassium bromate administration over 104 weeks resulted in renal adenocarcinomas in 3/20 (15%) and renal adenomas in 6/20 (30%) rats. At 104 weeks the mean number of renal cell tumors/rat was 1.25 compared with 0 in the controls. The combined incidence of follicular adenomas and adenocarcinomas of the thyroid was increased significantly (7/20 [35%]; $p < 0.01$) in rats receiving treatment for 104 weeks. The authors concluded that the minimum induction time for renal adenoma development was 26 weeks.

Kurokawa et al. (1987) exposed F344 rats (14-20/group) to water containing 500 ppm KBrO_3 (29.6-35.5 mg BrO_3^-/kg) for 13, 26, 39, or 52 weeks and studied the incidence of renal cell tumors at 104 weeks. The incidence of renal dysplastic foci, adenomas, and adenocarcinomas in rats exposed for 13-52 weeks was equal to or greater than that in rats receiving potassium bromate treatment continuously for 104 weeks (as reported elsewhere in Kurokawa et al., 1987). The combined incidence of renal adenomas and adenocarcinomas was significantly higher in exposed animals than in controls ($p < 0.001$). The authors concluded that the minimum dose necessary for the induction of renal adenomas and adenocarcinomas was a cumulative dose of 4 g KBrO_3/kg (3.08 g BrO_3^-/kg) and that the minimum treatment period for the induction of these tumors was 13 weeks. However, the authors also noted that the "true" minimum treatment time will be shorter than 13 weeks in experiments involving shorter exposure periods.

The genotoxicity of bromate has been evaluated in a variety of in vitro and in vivo systems. It has tested positive in the *Salmonella typhimurium* assay in the presence of metabolic activation and in an in vitro test for chromosomal aberrations that uses Chinese hamster fibroblasts (Ishidate et al., 1984). Dose-dependent increases in the number of aberrant metaphase cells were observed following single oral doses of potassium bromate to Long-Evans rats (Fuji et al., 1988). Bromate caused significant increases in the number of micronuclei following either i.p. injection (Hayashi et al., 1988; Awogi et al., 1992) or gavage dose (Hayashi et al., 1989; Nakajima et al., 1989) in mice. Also, i.p. injection of bromate in F344 rats resulted in significantly increased micronuclei in reticulocytes (Sai et al., 1992a). Bromate was cytotoxic, increased the frequency of cells with micronuclei, increased the number of chromosome aberrations, and increased DNA migration in a series of assays that used V79 Chinese hamster cells (Speit et al., 1999). Furthermore, potassium bromate clearly induced gene mutations at the HPRT locus of V79 Chinese hamster cells (Speit et al., 1999).

II.B. Quantitative Estimate of Carcinogenic Risk from Oral Exposure

II.B.1. Summary of Risk Estimates

II.B.1.1. Oral Slope Factor — $7\text{E}-1$ per (mg/kg-day)

II.B.1.2. Drinking Water Unit Risk* — $2\text{E}-5$ per $\mu\text{g}/\text{L}$.

*The unit risk should not be used if the water concentration exceeds $5\text{E}+2$ $\mu\text{g}/\text{L}$, because above this concentration the unit risk may not be appropriate.

II.B.1.3. Extrapolation Method — Time-to-tumor, Weibull

Drinking Water Concentrations at Specified Risk Levels

Risk Level

Concentration

E-4 (1 in 10,000)	5E+0 µg/L
E-5 (1 in 100,000)	5E-1 µg/L
E-6 (1 in 1,000,000)	5E-2 µg/L

II.B.2. Dose-Response Data (Carcinogenicity, Oral Exposure)

Tumor Type — testicular mesothelioma, renal tubular adenoma and carcinoma, and thyroid follicular cell adenoma and carcinoma

Test Animals — F344 rats, male

Route of Exposure — Ingestion, drinking water

Reference — DeAngelo et al., 1998

Administered dose (mg BrO ₃ ⁻ /kg-day)	Human Equivalent Dose ^b (mg BrO ₃ ⁻ /kg-day)	Incidence ^a		
		Testicular Mesothelioma	Thyroid Follicular Adenoma and Carcinoma	Kidney Adenoma and Carcinoma
0	0	0/71	0/60	1/69
1.1	0.3	4/73	4/63	1/67
6.1	1.7	5/73	2/67	6/71
12.9	3.5	11/71	5/58	3/62
28.7	7.9	31/67	17/54	18/56

^aIncludes tumor incidences from interim sacrifice groups.

^bHuman equivalent dose was estimated using body weight to the 0.75 power.

Tumor	ED ₁₀ ^a (mg/kg-day)	LED ₁₀ ^b (mg/kg-day)	0.1/LED ₁₀ ^c [(mg/kg-day) ⁻¹]	MLE of cancer potency ^d [(mg/kg-day) ⁻¹]	q1* ^e [(mg/kg-day) ⁻¹]
Mesothelioma	0.38	0.20	0.50	0.27	0.54
Kidney	1.3	0.59	0.17	0.08	0.18
Thyroid	2.1	1.1	0.09	0.05	0.10

^aEstimated human equivalent dose, obtained by body weight to the 3/4 power scaling factor, resulting in a 10% increase in cancer risk.

^b95% lower confidence limit on estimated human equivalent dose resulting in a 10% increase in cancer risk.

^cUnit cancer risk estimate based on drawing a straight line from the LED₁₀ as described for the linear extrapolation default in U.S. EPA's 1996, "Proposed Guidelines for Carcinogen Risk Assessment."

^dMaximum likelihood estimate of cancer potency from Weibull time-to-tumor model, calculated at a dose of 1 ng/kg-day.

^e95% upper confidence limit on cancer potency.

II.B.3. Additional Comments (Carcinogenicity, Oral Exposure)

Oral cancer risk was calculated based on the incidence of renal tubular tumors, thyroid follicular tumors, and testicular mesotheliomas from the DeAngelo et al. (1998) study. The analyses were conducted using the individual male rat data, including the 12-, 26-, 52-, and 77-week interim kill

data, for each site demonstrating an increased cancer incidence. Benign and malignant tumors were combined for the sites, that is, testicular mesotheliomas, kidney tubular adenomas and carcinomas, and thyroid follicular adenomas and carcinomas. Tumors were modeled for each site separately, and then the tumor site risks were combined to represent the total cancer risk. The multistage Weibull model was used in time-to-tumor analysis to help account for the early mortality in the highest dose groups. In the time-to-tumor analysis, tumor types are categorized as either fatal or incidental. Fatal tumors are those tumors thought to act rapidly to cause the animal to die, whereas incidental tumors are thought not to cause the death of the animal, or at least not rapidly. Each of the three tumor types observed in the U.S. EPA study was considered incidental (Wolf, 1998b). Thus, t_0 was set equal to 0. In addition, a one-stage model was the preferred model for each tumor type.

The highest cancer potency estimate for any individual tumor site was 0.54/mg/kg-day based on mesotheliomas. However, although time-to-tumor modeling does help account for decreased survival times in the rats, considering the tumor sites individually does not convey the total amount of risk potentially arising from multiple sites. To get some indication of the total unit risk from multiple tumor sites, assuming the tumors at these different sites arise independently, the MLEs of low-dose cancer potency from the Weibull time-to-tumor models were summed across tumor sites and an estimate of the 95% upper bound on the sum was calculated using a Monte Carlo analysis. The 95% upper bound for the total unit risk was 0.70/mg BrO_3^- /kg-day. A sensitivity analysis based on the contribution to variance reported that the variability associated with the risk estimate for the mesotheliomas was contributing 85% of the variance of the sum.

II.B.4. Discussion of Confidence (Carcinogenicity, Oral Exposure)

A low-dose linear extrapolation based on the U.S. EPA bromate study (DeAngelo et al., 1998) was conducted using a one-stage Weibull time-to-tumor model. This time-to-tumor model was selected because it can help account for the early mortality observed in treated animals as compared with control animals. Modeling was conducted on the individual tumor types, and cancer potency estimates were generated for the individual sites and for total risk from all three sites combined. Incidence of testicular mesotheliomas was the most sensitive response; however, the total cancer potency estimate was selected because it accounts for the total cancer risk posed by statistically significant tumors arising at multiple sites. It is assumed that these different tumors at different sites arise independently and that the different tumors are not necessarily induced by similar mechanisms. A source of uncertainty is the interspecies differences between rats and humans. Studies indicate that mice are less sensitive than rats to the effects of bromate. The reasons for this difference are unknown, and it is also unknown what the relative sensitivity between rats and humans is. Another uncertainty concerns how well the linear extrapolation predicts the low-dose human risks for bromate.

The major limitation of the bromate hazard characterization is the lack of data on the effects of long-term exposure to bromate in humans. The available human data are limited to case reports of toxicity following acute, accidental ingestion. Therefore, to extrapolate rat tumor data for bromate to the human situation, it must be assumed that humans will respond like the rat. Nevertheless, the choice of using the rat tumor data from DeAngelo et al. (1998) in the absence of human data is a reasonable assumption.

Overall, there is not enough evidence to give high confidence in a conclusion about any mode of carcinogenic action. Some studies show that bromate is weakly mutagenic and causes chromosomal aberrations (Ishidate et al., 1984; Fujie et al., 1988; Hayashi et al., 1988; Hayashi et al., 1989; Sai et al., 1992a; Speit et al., 1999). The mode of action by which bromate induces mutations and, thus, tumors, in the target organs is uncertain. Some studies show that bromate may generate oxygen radicals, which increase lipid peroxidation and damage DNA (Kasai et al., 1987; Sai et al., 1991; Sai et al., 1992a, 1992b, 1992c; Sai et al., 1994; Umemura et al., 1995). However, no data link this proposed mechanism to tumor induction. Thus, the available evidence is insufficient to establish this mechanism as a key event in the induction of tumors at the target organs observed.

Given the uncertainty about the mode of action, a science policy decision is made to use a low-dose linear extrapolation approach as more protective of public health. The cancer risk estimation presented for bromate is considered to be protective of susceptible groups, including children, given that the low-dose linear default approach is used as a conservative approach.

_II.C. Quantitative Estimate of Carcinogenic Risk from Inhalation Exposure

Lack of data by the inhalation route of exposure for bromate precludes the development of a quantitative estimate of carcinogenic risk from inhalation exposure.

_II.D. EPA Documentation, Review, and Contacts (Carcinogenicity Assessment)

__II.D.1. EPA Documentation

Source Document — U.S. EPA, 2001

This assessment was peer reviewed by external scientists. Their comments have been evaluated carefully and incorporated in the finalization of in this IRIS Summary. A record of these comments is included in Appendix A of the source document. *To review this appendix, exit to the toxicological review, Appendix A, Summary of and Response to External Peer Review Comments (PDF).*

__II.D.2. EPA Review (Carcinogenicity Assessment)

Agency Consensus Date 5/22/01

A comprehensive review of toxicological studies published through July 2006 was conducted. No new health effects data were identified that would be directly useful in the revision of the existing carcinogenicity assessment for Bromate and a change in the assessment is not warranted at this time. For more information, IRIS users may contact the IRIS Hotline at hotline.iris@epa.gov or 202-566-1676.

__II.D.3. EPA Contacts (Carcinogenicity Assessment)

Please contact the IRIS Hotline for all questions concerning this assessment or IRIS, in general, at (202)566-1676 (phone), (202)566-1749 (FAX), or hotline.iris@epa.gov (Internet address).

_III. [reserved]

_IV. [reserved]

_V. [reserved]

_VI. Bibliography

Substance Name — Bromate

CASRN — 15541-45-4

Last Revised — 06/06/2001

_VI.A. Oral RfD References

Benson, CI. (1951) Potassium bromate poisoning. Br Med J 1:1516.

DeAngelo, AB; George, MH; Kilburn, SR; et al. (1998) Carcinogenicity of potassium bromate administered in the drinking water to male B6C3F1 mice and F344/N rats. *Toxicol Pathol* 26(5):587-594.

Gradus (Ben-Ezer), D; Rhoads, M; Bergstrom, LB; et al. (1984) Acute bromate poisoning associated with renal failure and deafness presenting as hemolytic uremic syndrome. *Am J Nephrol* 4:188-191.

Kurokawa, Y; Hayashi, Y; Maekawa, A; et al. (1983) Carcinogenicity of potassium bromate administered orally to F344 rats. *J Natl Cancer Inst* 71:965-972.

Kurokawa, Y; Aoki, S; Matsushima, Y; et al. (1986a) Dose-response studies on the carcinogenicity of potassium bromate in F344 rats after long-term oral administration. *J Natl Cancer Inst* 77:977-982.

Kurokawa, Y; Takayama, S; Konishi, Y; et al. (1986b) Long-term in vivo carcinogenicity tests of potassium bromate, sodium hypochlorite and sodium chlorite conducted in Japan. *Environ Health Perspect* 69:221-236.

Kurokawa, Y; Maekawa, A; Takahashi, M; et al. (1990) Toxicity and carcinogenicity of potassium bromate--a new renal carcinogen. *Environ Health Perspect* 87:309-335.

Lichtenberg, R; Zeller, WP; Gatson, R; et al. (1989) Bromate poisoning. *J Pediatr* 114:891-894.

Lue, JN; Johnson, CE; Edwards, DL. (1988) Bromate poisoning from ingestion of professional hair-care neutralizer. *Clin Pharm* 7:66-70.

Mack, RB. (1988) Round up the usual suspects. Potassium bromate poisoning. *NC Med J* 49:243-245.

Matsumoto, I; Morizono, T; Paparella, MM. (1980) Hearing loss following potassium bromate: two case reports. *Otolaryngol Head Neck Surg* 88:625-629.

Nakano, K; Okada, S; Toyokuni, S; et al. (1989) Renal changes induced by chronic oral administration of potassium bromate or ferric nitrilotriacetate in Wistar rats. *Jpn Arch Intern Med* 36:41-47.

Quick, CA; Chole, RA; Mauer, SM. (1975) Deafness and renal failure due to potassium bromate poisoning. *Arch Otolaryngol* 101:494-495.

U.S. EPA. (2001) Toxicological review of bromate. Integrated Risk Information System. <http://www.epa.gov/iris>.

Warshaw, BL; Carter, MC; Hymes, LC; et al. (1985) Bromate poisoning from hair permanent preparations. *Pediatrics* 76(6):975-978.

Watanabe, T; Abe, T; Satoh, M; et al. (1992) Two children with bromate intoxication due to ingestion of the second preparation for permanent hair waving. *Acta Paediatr Jpn* 34(6):601-605.

Wolf, DC. (1998a) Personal communication from Douglas Wolf, National Health and Environmental Effects Research Laboratory, U.S. EPA, to Vicki Dellarco, Office of Water, U.S. EPA. February 20, 1998.

_VI.B. Inhalation RfC References

None.

VI.C. Carcinogenicity Assessment References

- Awogi, T; Murata, K; Uejima, M; et al. (1992) Induction of micronucleated reticulocytes by potassium bromate and potassium chromate in CD-1 male mice. *Mutat Res* 278(2-3):181-185.
- DeAngelo, AB; George, MH; Kilburn, SR; et al. (1998) Carcinogenicity of potassium bromate administered in the drinking water to male B6C3F1 mice and F344/N rats. *Toxicol Pathol* 26(5):587-594.
- Fujie, K; Shimazu, H; Matsuda, M; et al. (1988) Acute cytogenetic effects of potassium bromate on rat bone marrow cells in vivo. *Mutat Res* 206:455-458.
- Hayashi, M; Kishi, M; Sofuni, T; et al. (1988) Micronucleus tests in mice on 39 food additives and eight miscellaneous chemicals. *Food Chem Toxicol* 26:487-500.
- Hayashi, M; Sutou, S; Shimada, H; et al. (1989) Difference between intraperitoneal and oral gavage application in the micronucleus test: The 3rd collaborative study by CSGMT/JEMS-HMS. *Mutat Res* 223:329-344.
- Ishidate, M; Sofuni, T; Yoshikawa, K; et al. (1984) Primary mutagenicity screening of food additives currently used in Japan. *Food Chem Toxicol* 22:623-636.
- Kasai, H; Nishimura, S; Kurokawa, Y; et al. (1987) Oral administration of the renal carcinogen, potassium bromate, specifically produces 8-hydroxydeoxyguanosine in rat target organ DNA. *Carcinogenesis* 8:1959-1961.
- Kurata, Y; Diwan, BA; Ward, JM. (1992) Lack of renal tumour-initiating activity of a single dose of potassium bromate, a genotoxic renal carcinogen in male F344/NCr rats. *Food Chem Toxicol* 30(3):251-259.
- Kurokawa, Y; Hayashi, T; Maekawa, A; et al. (1983) Carcinogenicity of potassium bromate administered orally to F344 rats. *J Natl Cancer Inst* 71: 965-972.
- Kurokawa, Y; Aoki, S; Matsushima, Y; et al. (1986a) Dose-response studies on the carcinogenicity of potassium bromate in F344 rats after long-term oral administration. *J Natl Cancer Inst* 77:977-982.
- Kurokawa, Y; Takayama, S; Konishi, Y; et al. (1986b) Long-term in vivo carcinogenicity tests of potassium bromate, sodium hypochlorite and sodium chlorite conducted in Japan. *Environ Health Perspect* 69:221-236.
- Kurokawa, Y; Matsushima, Y; Takamura, N; et al. (1987). Relationship between the duration of treatment and the incidence of renal cell tumors in male F344 rats administered potassium bromate. *Jpn J Cancer Res* 78:358-364.
- Matsushima, Y; Takamura, N; Imazawa, T; et al. (1986) Lack of carcinogenicity of potassium bromate after subcutaneous injection to newborn mice and newborn rats. *Sci Rep Res Inst Tohoku Univ* 33:22-26.
- Nakajima, M; Kitazawa, M; Oba, K; et al. (1989) Effect of route of administration in the micronucleus test with potassium bromate. *Mutat Res* 223:399-402.
- NTP. (1998) National Toxicology Program Historical Controls Database. <http://ntp-server.niehs.nih.gov/?objectid=92E61F1B-F1F6-975E-7D3BED551F07DC0A>.

Sai, K; Takagi, A; Umemura, T; et al. (1991) Relation of 8-hydroxydeoxyguanosine formation in rat kidney to lipid peroxidation, glutathione level and relative organ weight after a single administration of potassium bromate. *Jpn J Cancer Res* 82(2):165-169.

Sai, K; Hayashi, M; Takagi, A; et al. (1992a) Effects of antioxidants on induction of micronuclei in rat peripheral blood reticulocytes by potassium bromate. *Mutat Res* 269(1):113-118.

Sai, K; Uchiyama, S; Ohno, Y; et al. (1992b) Generation of active oxygen species in vitro by the interaction of potassium bromate with rat kidney cell. *Carcinogenesis* 13(3):333-339.

Sai, K; Umemura, T; Takagi, A; et al. (1992c) The protective role of glutathione, cysteine and vitamin C against oxidative DNA damage induced in rat kidney by potassium bromate. *Jpn J Cancer Res* 83(1):45-51.

Sai, K; Tyson, CA; Thomas, DW; et al. (1994) Oxidative DNA damage induced by potassium bromate in isolated rat renal proximal tubules and renal nuclei. *Cancer Lett* 87:1-7.

Speit, G; Haupter, S; Schutz, P; et al. (1999) Comparative evaluation of the genotoxic properties of potassium bromate and potassium superoxide in V79 Chinese hamster cells. *Mutat Res* 439:213-221.

Umemura, T; Sai, K; Takagi, A; et al. (1995) A possible role for oxidative stress in potassium bromate (KBrO₃) carcinogenesis. *Carcinogenesis* 16:593-597.

Wolf, GW; Kaiser, L. (1996) Final report. Sodium bromate: short term reproductive and developmental toxicity study when administered to Sprague-Dawley rats in the drinking water. Submitted to National Toxicology Program, National Institute of Environmental Health Sciences. NTP/NIEHS No.: NOI-ES-15323.

U.S. EPA. (1986) Guidelines for carcinogen risk assessment. *Federal Register* 51(185):33992-34003.

U.S. EPA. (1996) Proposed guidelines for carcinogen risk assessment; notice. April 23, 1996. *Fed. Reg.* 61, No. 79: 17960-18011.

U.S. EPA. (2001) Toxicological review of bromate. Integrated Risk Information System. <http://www.epa.gov/iris>.

Wolf, DC. (1998a) Personal communication from Douglas Wolf, National Health and Environmental Effects Research Laboratory, U.S. EPA, to Vicki Dellarco, Office of Water, U.S. EPA. February 20, 1998.

Wolf, DC. (1998b) Personal communication from Douglas Wolf, National Health and Environmental Effects Research Laboratory, U.S. EPA, to Jennifer Jinot, National Center for Environmental Assessment, U.S. EPA. January 12, 1998.

_VII. Revision History

Substance Name — Bromate
CASRN — 15541-45-4

Date	Section	Description
------	---------	-------------

04/01/1997	III., IV., V.	Drinking Water Health Advisories, EPA Regulatory Actions, and Supplementary Data were removed from IRIS on or before April 1997. IRIS users were directed to the appropriate EPA Program Offices for this information.
06/06/01	I.A., II.,VI	RfD and carcinogenicity assessments first on line.
10/28/2003	I.A.6., I.B.6., II.D.2.	Screening-Level Literature Review Findings message has been added.
09/28/2006	I.A.6., I.B.6., II.D.2.	Screening-Level Literature Review Findings message has been removed and replaced by comprehensive literature review conclusions.

_VIII. Synonyms

Substance Name — Bromate

CASRN — 15541-45-4

Last Revised — 06/06/2001

- 15541-45-4
- Bromate
- Bromate(1-), bromochloro-, rubidium
- Bromic acid, potassium salt
- Bromic acid, sodium salt
- Bromic acid, zinc salt

IRIS Home

Chronic Health Hazards for Non-Carcinogenic Effects

Reference Dose for Chronic Oral Exposure (RfD)

- Oral RfD
Summary
- Principal and
Supporting
Studies
- Uncertainty and
Modifying Factors
- Additional
Studies/Comments
- Confidence in the
Oral RfD
- EPA
Documentation
and Review

Reference Concentration for Chronic Inhalation Exposure (RfC)

- Inhalation RfC
Summary
- Principal and
Supporting
Studies
- Uncertainty and
Modifying Factors

- Additional Studies/Comments
- Confidence in the Inhalation RfC
- EPA Documentation and Review

Carcinogenicity Assessment for Lifetime Exposure

Evidence for Human Carcinogenicity

- Weight-of-Evidence Characterization
- Human Carcinogenicity Data
- Animal Carcinogenicity Data
- Supporting Data for Carcinogenicity

Quantitative Estimate of Carcinogenic Risk from Oral Exposure

- Summary of Risk Estimates
- Dose-Response Data
- Additional Comments
- Discussion of Confidence

Quantitative Estimate of Carcinogenic Risk from Inhalation Exposure

- Summary of Risk Estimates
- Dose-Response Data
- Additional Comments
- Discussion of Confidence
- EPA Documentation, Review and, Contacts

Bibliography

Revision History

Synonyms



Integrated Risk Information System

 You are here: [EPA Home](#) [Research](#) [Environmental Assessment](#) [IRIS](#) [IRIS Summaries](#)

N-Nitrosodimethylamine (CASRN 62-75-9)

[view QuickView](#)
[MAIN CONTENTS](#)



[List of IRIS Substances](#)
☐ [S Su](#) [aries](#) [o icological](#)
[views](#)

☐ [Entire](#) [S Website](#)

Reference Dose for Chronic Oral Exposure (RfD)

0045

N-Nitrosodimethylamine; CASRN 62-75-9

Human health assessment information on a chemical substance is included in the IRIS database only after a comprehensive review of toxicity data, as outlined in the [IRIS assessment development process](#). Sections I (Health Hazard Assessments for Noncarcinogenic Effects) and II (Carcinogenicity Assessment for Lifetime Exposure) present the conclusions that were reached during the assessment development process. Supporting information and explanations of the methods used to derive the values given in IRIS are provided in the [guidance documents located on the IRIS website](#).

STATUS OF DATA FOR N-Nitrosodimethylamine

File First On-Line 01/31/1987

Category (section)	Status	Last Revised
Oral RfD Assessment (I.A.)	no data	
Inhalation RfC Assessment (I.B.)	no data	09/01/1992
Carcinogenicity Assessment (II.)	on-line	07/01/1993

I. Chronic Health Hazard Assessments for Noncarcinogenic Effects

I.A. Reference Dose for Chronic Oral Exposure (RfD)

Substance Name — N-Nitrosodimethylamine

CASRN — 62-75-9

Primary Synonym — Dimethylnitrosamine

Not available at this time.

I.B. Reference Concentration for Chronic Inhalation Exposure (RfC)

Substance Name — N-Nitrosodimethylamine

CASRN — 62-75-9

Primary Synonym — Dimethylnitrosamine

Not available at this time.

__II. Carcinogenicity Assessment for Lifetime Exposure

Substance Name — N-Nitrosodimethylamine

CASRN — 62-75-9

Primary Synonym — Dimethylnitrosamine

Last Revised — 07/01/1993

Section II provides information on three aspects of the carcinogenic assessment for the substance in question; the weight-of-evidence judgment of the likelihood that the substance is a human carcinogen, and quantitative estimates of risk from oral exposure and from inhalation exposure. The quantitative risk estimates are presented in three ways. The slope factor is the result of application of a low-dose extrapolation procedure and is presented as the risk per (mg/kg)/day. The unit risk is the quantitative estimate in terms of either risk per ug/L drinking water or risk per ug/cu.m air breathed. The third form in which risk is presented is a drinking water or air concentration providing cancer risks of 1 in 10,000, 1 in 100,000 or 1 in 1,000,000. The rationale and methods used to develop the carcinogenicity information in IRIS are described in The Risk Assessment Guidelines of 1986 (EPA/600/8-87/045) and in the IRIS Background Document. IRIS summaries developed since the publication of EPA's more recent Proposed Guidelines for Carcinogen Risk Assessment also utilize those Guidelines where indicated (Federal Register 61(79):17960-18011, April 23, 1996). Users are referred to Section I of this IRIS file for information on long-term toxic effects other than carcinogenicity.

__II.A. Evidence for Human Carcinogenicity

__II.A.1. Weight-of-Evidence Characterization

Classification — B2; probable human carcinogen

Basis — Induction of tumors at multiple sites in both rodents and nonrodent mammals exposed by various routes

__II.A.2. Human Carcinogenicity Data

Human exposure to nitrosamines results from contact with mixtures containing these compounds (e.g., cutting oils, tobacco products). Because of potential confounding by the other substances in these mixtures, data from human exposure is of limited use in the evaluation of carcinogenicity of individual nitrosamines.

__II.A.3. Animal Carcinogenicity Data

There is a large database on the carcinogenicity of nitrosamines, most of which pertains to structure-activity relationships rather than to dose- response. N-Nitrosodimethylamine produced liver tumors in BD rats when administered in drinking water (Druckrey et al., 1967) and in female Porton rats when administered in the diet (Terracini et al., 1967). Magee et al. (1976) state that dimethylnitrosamine produced many hemangiomas and some parenchymal cell tumors in the livers of rats after oral administration.

N-Nitrosodimethylamine acts as a transplacental carcinogen when administered to pregnant rats, mice, and Syrian golden hamsters by several routes (Tomatis, 1973). Increases in lung, liver, and kidney tumors were observed in both Wistar rats and Balb/C mice exposed by inhalation. Mink are very sensitive to the effects of dimethylnitrosamine, developing tumors when fed 0.05 mg/kg 2

days/week (NAS, 1978).

Peto et al. (1984) exposed groups of Colworth rats (36/sex/dose) to 15 concentrations of N-nitrosodimethylamine in drinking water (0.033-16.896 ppm). Daily water consumption was 41 mL/kg for males and 72 mL/kg for females. Tumors were generally of hepatic origin, and these tumors constituted the only cause of mortality considered treatment-related. Tumor incidences for each treatment group were not reported, but pooled data indicated possible positive trends for lung, skin, seminal vesicle, lymphatic/hematopoietic system, and liver tumors.

__II.A.4. Supporting Data for Carcinogenicity

N-Nitrosodimethylamine is mutagenic for *Escherichia coli*, *Salmonella typhimurium* and *Neurospora crassa*, produces mitotic recombination in *Sacharoyus cerevesiae*, recessive lethal mutations in *Drosophilla melanogaster*, and chromosomal aberrations in mammalian cells. Positive responses in bacterial cells are dependent upon the addition of a mammalian metabolism system (Montesano and Bartsch, 1976). Dimethylnitrosamine is structurally related to known carcinogens.

__II.B. Quantitative Estimate of Carcinogenic Risk from Oral Exposure

__II.B.1. Summary of Risk Estimates

Oral Slope Factor — $5.1\text{E}+1$ per (mg/kg)/day

Drinking Water Unit Risk — $1.4\text{E}-3$ per ($\mu\text{g/L}$)

Extrapolation Method — Weibull, extra risk

Drinking Water Concentrations at Specified Risk Levels:

Risk Level	Concentration
E-4 (1 in 10,000)	$7\text{E}-2$ $\mu\text{g/L}$
E-5 (1 in 100,000)	$7\text{E}-3$ $\mu\text{g/L}$
E-6 (1 in 1,000,000)	$7\text{E}-4$ $\mu\text{g/L}$

__II.B.2. Dose-Response Data (Carcinogenicity, Oral Exposure)

Tumor Type — liver

Test Animals — rat/Colworth, female

Route — drinking water

Reference — Peto et al., 1984

Specific tumor incidences were not published. Data from Peto et al. (1984) on incidence of liver tumors of all types in female rats were shown to follow this relationship:

$$\text{CI} = 51.45 (d + 0.1) **6 \times t**7$$

where: CI =cumulative incidence
d =dose (mg/kg/day)
t = time in years

Using procedures described in U.S. EPA (1980) to correct for background response, the increased risk of 1 ug/kg/day for 3 years = $7.8\text{E-}3$ or a slope factor for rats of 7.8 per (mg/kg)/day. The slope factor was thus calculated to be 51 per (mg/kg)/day by using the cube root of the ratio of the assumed human body weight (70 kg) to the reported rat body weight of (250 g).

__II.B.3. Additional Comments (Carcinogenicity, Oral Exposure)

The unit risk should not be used if the water concentration exceeds 7 ug/L, since above this concentration the unit risk may not be appropriate.

__II.B.4. Discussion of Confidence (Carcinogenicity, Oral Exposure)

Although specific tumor incidence data was not reported, it appears that large numbers of animals were treated over a wide dose range. Both tumor incidence and latency were shown to be dose-dependent. The study was designed specifically for analysis using the Weibull model. A slope factor based on data by Druckrey et al. (1972) was determined by use of a one-hit model to be 26 per (mg/kg)/day.

__II.C. Quantitative Estimate of Carcinogenic Risk from Inhalation Exposure

__II.C.1. Summary of Risk Estimates

Inhalation Unit Risk — $1.4\text{E-}2$ per ($\mu\text{g}/\text{cu.m}$)

Extrapolation Method — Weibull, extra risk

Air Concentrations at Specified Risk Levels:

Risk Level	Concentration
E-4 (1 in 10,000)	$7\text{E-}3$ $\mu\text{g}/\text{cu.m}$
E-5 (1 in 100,000)	$7\text{E-}4$ $\mu\text{g}/\text{cu.m}$
E-6 (1 in 1,000,000)	$7\text{E-}5$ $\mu\text{g}/\text{cu.m}$

__II.C.2. Dose-Response Data for Carcinogenicity, Inhalation Exposure

Calculated from data in Section II.B.2.

__II.C.3. Additional Comments (Carcinogenicity, Inhalation Exposure)

The above unit risk should not be used if the air concentration exceeds 0.7 $\mu\text{g}/\text{cu.m}$, since above this concentration the unit risk may not be appropriate.

__II.C.4. Discussion of Confidence (Carcinogenicity, Inhalation Exposure)

See II.B.4.

__II.D. EPA Documentation, Review, and Contacts (Carcinogenicity Assessment)

__II.D.1. EPA Documentation

Source Document — U.S. EPA, 1980, 1986

The values in the Health and Environmental Effects Profile for Nitrosamines (U.S. EPA, 1986) received Agency Review.

__II.D.2. EPA Review (Carcinogenicity Assessment)

Agency Work Group Review — 06/26/1986, 08/13/1986, 10/29/1986

Verification Date — 10/29/1986

Screening-Level Literature Review Findings — A screening-level review conducted by an EPA contractor of the more recent toxicology literature pertinent to the cancer assessment for N-Nitrosodimethylamine conducted in September 2002 identified one or more significant new studies. IRIS users may request the references for those studies from the IRIS Hotline at hotline.iris@epa.gov or (202)566-1676.

__II.D.3. EPA Contacts (Carcinogenicity Assessment)

Please contact the IRIS Hotline for all questions concerning this assessment or IRIS, in general, at (202)566-1676 (phone), (202)566-1749 (FAX) or hotline.iris@epa.gov (internet address).

__III. [reserved]

__IV. [reserved]

__V. [reserved]

__VI. Bibliography

Substance Name — N-Nitrosodimethylamine

CASRN — 62-75-9

Primary Synonym — Dimethylnitrosamine

Last Revised — 03/01/1990

__VI.A. Oral RfD References

None

__VI.B. Inhalation RfC References

None

__VI.C. Carcinogenicity Assessment References

Druckrey, H., R. Preussmann, S. Ivankovic and D. Schmaehl, 1967. Organotropism and carcinogenic effects of 65 different N-nitroso compounds in BD-rats. *Z. Krebsforsch.* 69(2): 103-201.

Druckrey, H., S. Ivankovic, R. Preussmann, K.J. Zulch and H.D. Mennel, 1972. Selective induction of malignant tumors of the nervous system by resorptive carcinogens. In: *Experimental Biology of Brain Tumors*. p. 85-112.

Magee, P.N., R. Montesano and R. Preussmann. 1976. N-nitroso compounds and related carcinogens. ACS Monograph. 173: 491-625.

Montesano, R. and H. Bartsch. 1976. Mutagenic and carcinogenic N-nitroso compounds: Possible environmental Hazards. Mutat. Res. 32: 179-228.

NAS (National Academy of Sciences). 1978. Nitrates: An environmental assessment. A report prepared by the panel on nitrates of the Coordinating Comm. Sci. Tech. Assess. Environ. Pollut., Washington, DC.

Peto, R., R. Gray, P. Brantom and P. Grasso. 1984. Nitrosamine carcinogenesis in 5120 rodents: Chronic administration of sixteen different concentrations of NDEA, NDMA, NPYR and NPIP in the water of 4440 inbred rats, with parallel studies on NDEA alone of the effect of age of starting (3, 6 or 20 weeks) and of species (rats, mice, hamsters). IARC Sci. Publ. 57: 627-665.

Terracini, B., P.N. Magee and J.M. Barnes. 1967. Hepatic pathology in rats on low dietary levels of dimethylnitrosamine. Br. J. Cancer. 21: 559-565.

Tomatis, L. 1973. Transplacental carcinogenesis. In: Modern Trends in Oncology. Part I, R.W. Raven, Ed. Butterworths, London.

U.S. EPA 1980. Ambient Water Quality Criteria for Nitrosamines. Prepared by the Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Cincinnati, OH for the Office of Water Regulations and Standards, Washington, DC. EPA 440/5-80-064. NTIS PB 81-117756.

U.S. EPA. 1986. Health and Environmental Effects Profile for Nitrosamines. Prepared by the Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Cincinnati, OH for the Office of Solid Waste and Emergency Response, Washington, DC.

VII. Revision History

Substance Name — N-Nitrosodimethylamine

CASRN — 62-75-9

Primary Synonym — Dimethylnitrosamine

Date	Section	Description
03/31/1987	IV.	RQ added
09/30/1987	IV.	Regulatory Action section on-line
03/01/1988	II.A.1.	Text clarified
03/01/1988	II.B.1.	Number rounded off
03/01/1988	II.B.3.	Text revised
03/01/1988	II.B.4.	Confidence statement revised
03/01/1988	II.C.1.	Number rounded off
03/01/1988	II.C.4.	Confidence statement revised
03/01/1988	II.D.3.	Secondary contact changed
02/01/1990	VI.	Bibliography on-line
03/01/1990	VI.C.	Druckrey & Peto references clarified

01/01/1991	II.	Text edited
01/01/1991	II.C.1.	Inhalation slope factor removed (global change)
01/01/1992	IV.	Regulatory actions updated
09/01/1992	I.B.	Inhalation RfC now under review
07/01/1993	II.D.3.	Secondary contact's phone number changed
08/01/1995	I.B.	EPA's RfD/RfC and CRAVE workgroups were discontinued in May, 1995. Chemical substance reviews that were not completed by September 1995 were taken out of IRIS review. The IRIS Pilot Program replaced the workgroup functions beginning in September, 1995.
04/01/1997	III., IV., V.	Drinking Water Health Advisories, EPA Regulatory Actions, and Supplementary Data were removed from IRIS on or before April 1997. IRIS users were directed to the appropriate EPA Program Offices for this information.
12/03/2002	II.D.2.	Screening-Level Literature Review Findings message has been added.

_VIII. Synonyms

Substance Name — N-Nitrosodimethylamine

CASRN — 62-75-9

Primary Synonym — Dimethylnitrosamine

Last Revised — 01/31/1987

- 62-75-9
- dimethylamine, N-nitroso
- dimethylnitrosamin
- Dimethylnitrosamine
- dimethylnitrosoamine
- DMNA; DMN
- methylamine, N-nitrosodi-
- NDMA
- nitrosodimethylamine
- Nitrosodimethylamine, N-
- N-methyl-N-nitrosomethanamine
- N,N-dimethylnitrosamine
- N-Nitrosodimethylamine
- RCRA waste number P082

IRIS Home
Chronic Health
Hazards for
Non-Carcinogenic
Effects

Reference Dose for
Chronic Oral
Exposure (RfD)

- Oral RfD Summary
- Principal and Supporting Studies
- Uncertainty and Modifying Factors
- Additional

- Studies/Comments
- Confidence in the Oral RfD
- EPA Documentation and Review

Reference

Concentration for Chronic Inhalation Exposure (RfC)

- Inhalation RfC Summary
- Principal and Supporting Studies
- Uncertainty and Modifying Factors
- Additional Studies/Comments
- Confidence in the Inhalation RfC
- EPA Documentation and Review

Carcinogenicity Assessment for Lifetime Exposure

Evidence for Human Carcinogenicity

- Weight-of-Evidence Characterization
- Human Carcinogenicity Data
- Animal Carcinogenicity Data
- Supporting Data for Carcinogenicity

Quantitative Estimate of Carcinogenic Risk from Oral Exposure

- Summary of Risk Estimates
- Dose-Response Data
- Additional Comments
- Discussion of Confidence

Quantitative Estimate of Carcinogenic Risk from Inhalation Exposure

- Summary of Risk Estimates
- Dose-Response Data
- Additional Comments

- Discussion of Confidence
- EPA Documentation, Review and, Contacts

Bibliography

Revision History

Synonyms



United States Department of the Interior

FISH AND WILDLIFE SERVICE
Ecological Services
Sacramento Field Office
2800 Cottage Way, Room E-1803
Sacramento, California 95825-1846

In Reply Refer To:
1-1-93-F-35

September 9, 1993

Memorandum

To: Regional Director, Bureau of Reclamation,
Sacramento, California

From: Acting Field Supervisor, Ecological Services
Sacramento Field Office, Sacramento, California (ES)

Subject: Formal Consultation on Effects of the Proposed Los Vaqueros
Reservoir Project on Delta Smelt, Contra Costa County, California

This responds to your request of April 7, 1992, for formal consultation pursuant to Section 7(a)(2) of the Endangered Species Act of 1973, as amended (Act). This consultation addresses the effects of the proposed Los Vaqueros Project (LVP) on the threatened delta smelt (*Hypomesus transpacificus*). Prior to listing, a request for conferencing, pursuant to 50 CFR § 402.10 was submitted to the Service on August 26, 1992. Representatives from the Fish and Wildlife Service (Service), Bureau of Reclamation (Reclamation), Contra Costa Water District (CCWD), Jones and Stokes Associates (JSA), and Environmental Protection Agency have met on various occasions since January 12, 1993, to discuss the proposal. In a memorandum from Reclamation to the Service dated February 8, 1991, CCWD was designated as the non-Federal representative for endangered species issues. Effects of this action on terrestrial species are being addressed in a separate, concurrent consultation with the Service (1-1-92-F-48). Effects of this project on the vernal pool ferry shrimp are being addressed in a separate conference (1-1-93-F-35).

Reclamation and CCWD currently are addressing effects of LVP on other fish species including the threatened winter-run chinook salmon (*Oncorhynchus tshawytscha*), and two petitioned species--longfin smelt (*Spirinchus thaleichthys*) and Sacramento splittail (*Pogonichthys macrolepidotus*). The Service's Regional Director has directed that effects of all projects on longfin smelt and Sacramento splittail concurrently be considered when consulting on delta smelt. Appendix A gives information concerning these two species.

This biological opinion does not address all of the interrelated and interdependent effects of this action. Effects of the Central Valley Project (CVP) operation on the bald eagle (*Haliaeetus leucocephalus*), California clapper rail (*Rallus longirostris obsoletus*), and salt marsh harvest mouse (*Reithrodontomys raviventris*), were addressed in another biological opinion (Ref. No. 1-1-93-F-10). Effects of the entire CVP on the delta smelt (*Hypomesus transpacificus*) are being addressed in a concurrent consultation (Ref. No. 1-1-93-F-32). Effects of the CVP in the Friant Division service area were addressed in the Friant biological opinion (Ref. No. 1-1-91-F-22). Reclamation has agreed to address listed species effects in the remaining service areas of the CVP in future consultation by letter dated April 8, 1993.

This biological opinion is based on: (1) verbal comments received from Reclamation and CCWD at various meetings; (2) Contra Costa Water District's Section 404(b)(1) Alternatives Analysis for Meeting Water Quality and

Reliability Objectives, prepared by CCWD with technical assistance from James M. Montgomery, Consulting Engineers, Inc. and JSA, dated August 1990; (3) Appendix B: Contra Costa Water District's Statement on Regional Participation in a Los Vaqueros Reservoir Project, prepared by CCWD with technical assistance from James M. Montgomery, Consulting Engineers, Inc., and JSA, dated September 1990; (4) Los Vaqueros: A Water Quality and Resource Management Project Sponsored by Contra Costa Water District-Results of Supplemental Biological Inventories Conducted for the Los Vaqueros Project in and adjacent to Kellogg Creek Watershed, prepared for CCWD by JSA with technical assistance from James M. Montgomery, Consulting Engineers, Inc., dated January 1991; (5) Los Vaqueros: A Water Quality and Resource Management Project Sponsored By Contra Costa Water District-Scoping Report for the Contra Costa Water District Los Vaqueros Project Stage 2 EIR/ELS, prepared for CCWD by JSA, dated March 1991; (6) Appendix C. Section 404(b)(1) Alternatives Analysis for Relocating Vasco Road (November 1, 1991), prepared for CCWD by JSA, dated November 1, 1991; (7) Statement of John S. Gregg before the State Water Resources Control Board State Of California in the Water Rights Hearing For The Los Vaqueros Project, LVPWR-CCWD Exhibit 1-A, dated October 14-16, 1992; (8) miscellaneous materials provided by Reclamation, CCWD, and JSA during the consultation process; (9) published information that concerns habitat requirements for delta smelt; (10) unpublished information in Service files; (11) the National Marine Fisheries Service's (NMFS) biological opinion for winter-run chinook salmon of February 12, 1993, on the Central Valley Project-Operations Criteria and Plan (CVP-OCAP); (12) the Service's biological opinion of May 26, 1993, on the CVP-OCAP for delta smelt; and (13) the NMFS biological opinion for winter-run chinook salmon of March 18, 1993 on the proposed LVP. In addition, the California State Water Resources Control Board's (SWRCB) Water Right Decision 1485 (D-1485) and the NMFS long-term winter-run chinook salmon biological opinion on CVP-OCAP are important in defining the environmental baseline for the project. This is because D-1485 defines baseline conditions and Reclamation currently is implementing provisions of the long-term winter-run chinook salmon and 1993 delta smelt CVP-OCAP biological opinions.

Biological Opinion

It is our biological opinion that the proposed operations of LVP based on requirements set forth in D-1485 and including modifications from the long-term CVP-OCAP biological opinion for winter-run chinook salmon and the Los Vaqueros biological opinion for winter-run chinook salmon are not likely to jeopardize the continued existence of the delta smelt. Critical habitat for this species has not been designated; therefore, none will be adversely modified or destroyed.

Description of the Proposed Action

Please refer to the following document for a detailed project description: Biological Assessment for Federal Threatened, Endangered, and Candidate Species for the Los Vaqueros Project, prepared for Reclamation and CCWD by JSA, dated August 6, 1992. A March 9, 1993, meeting between the Service, Reclamation, and CCWD clarified some of the project elements described in the biological assessment.

In brief, Reclamation and CCWD propose to construct and operate the LVP, including (1) the storage of 100,000 acre feet (af) of water in the Los Vaqueros Reservoir (LVR) in the Kellogg Creek Watershed; (2) a new diversion and water pumping facilities along Old River; (3) facilities for the delivery of water to the LVR and to the Contra Costa Canal (CCC) System; and (4) amendment of the water supply and facilities repayment agreement between CCWD and Reclamation I75r-3401 Amended which entitles CCWD to maximum CVP deliveries of 195,000 af in any year. On March 9, 1993, it was agreed by the Service, Reclamation, and CCWD that deliveries with LVP would not exceed the

annual maximum 148,000 af under this biological opinion. The annual maximum of 148,000 af per year approximates the current maximum delivery through the CCC System.

CCWD currently provides water from the Sacramento-San Joaquin Delta to approximately 400,000 customers. The LVP is proposed to improve the quality of water supplied to CCWD customers, minimize seasonal quality changes, and improve the reliability of supply. In general, water would be pumped from the proposed supplemental diversion on Old River at times of relatively high water quality and either: 1) stored in the reservoir for blending with diversions occurring at the existing Rock Slough intake when water quality is relatively low or 2) diverted directly to the CCWD service area. Diversions from the Delta are reduced whenever stored water is taken from the proposed reservoir for delivery to the service area. Water may be taken from the supplemental LVP intake for direct delivery to customers with or without blending.

Existing System

CCWD currently maintains and operates raw water distribution facilities and water treatment and treated water distribution facilities. The CCC, pumping plants, and Rock Slough intake are owned by Reclamation. CCWD presently supplies raw water to the Antioch, Diablo Water District, Pittsburg, Southern California Water Company that serves West Pittsburg (Bay Point), Martinez, 10 major industries, 36 smaller industries and businesses, and approximately 35 agricultural users. Approximately 400,000 customers receive water from CCWD, including wholesale and retail customers throughout eastern and north-central Contra Costa County (Figure 1).

The CCC facilities are owned by Reclamation and operated by CCWD; they are CCWD's principal raw water supply and delivery system. These facilities receive water by means of unregulated and regulated flows from Reclamation's Central Valley Project (CVP) water supply and storage releases from Shasta, Folsom, and Trinity Lakes into the Sacramento River. Diversions and rediversions are then made in the Delta to CCWD's system at Rock Slough. Under Water Service Contract 175r-3401 (amended) with Reclamation, CCWD could divert up to 195,000 af per year (af/yr) of water from Rock Slough or other points of diversion in the Delta. Currently, CCWD uses approximately 135,000 af/yr of water.

CCWD also can divert up to 26,780 af/yr of water from Mallard Slough in the Delta (Water Rights License No. 3167 and Permit No. 19856). This diversion has been made in lieu of diverting water through the CCC; only minor diversions have been made from Mallard Slough in recent years because of unacceptable water quality. Diversions from the Mallard Slough intake, which is directly south of Chipps Island, are started when water quality is about 100 ppm chlorides or better (100 ppm chlorides is about 0.18 ppt salinity) and continue while water quality is acceptable. Water diversions are halted as the water quality rises above 100 ppm chlorides. Since 1968, average pumping was 6,600 af per year, with a total 2,500 af from 1987-1992.

A 4-mile long, earth-lined channel with a capacity of approximately 328 cubic feet per second (cfs) delivers water from Rock Slough to Oakley, the site of the first of four CCC pumping plants. The unscreened intake has no control structures except for a trash rack at Rock Slough. Over the course of 3 miles, a series of four pumping plants lift water from sea level in the Delta to about the 124-foot elevation. The 44-mile long CCC has numerous appurtenant structures, including siphons, culverts, bridges, checks, wasteways, and two tunnels. Raw water is delivered to customers through numerous turnouts along the canal.

The CCWD system is dependent on nearly continuous operation of all four pumping plants along the CCC. If any of these facilities were shut down

because of a Delta levee failure, power failure, severe earthquake, drought, Delta chemical spill, or other Delta water quality problems, CCWD could meet unconstrained water demands for only a few peak days by drawing from existing storage reservoirs. Contra Loma and Martinez Reservoirs (Federal facilities), and Mallard Reservoir (a CCWD facility) provide CCWD's raw water storage. The three reservoirs have a combined usable storage of about 5,000 af. Other raw water storage is provided by the City of Antioch and some industries.

Proposed Los Vaqueros Project

Los Vaqueros Reservoir

The project will deliver Delta water to a main storage facility with a capacity of 100,000 af at the LVR site (Figure 2) for later release to the CCC. These facilities will provide offstream storage of high-quality water for use during the seasonal intrusion of salinity into Delta waters. The reservoir also will provide emergency water storage. The allocation of water in the reservoir consists of 56,000 af of emergency storage, 30,000 af of water quality enhancement (including up to 12,500 af for fisheries protection purposes), approximately 10,000 af of unused storage, and 4,000 af of evaporation storage. The reservoir size was designed to provide an emergency supply equal to 90 days at the peak 3-month demand level at buildout during wet, above normal and below normal years, and assuming customer cutbacks of 25% during the emergency. During a critical dry year or series of such years, up to 26,000 af of this emergency storage may be used for water quality blending, in addition to 30,000 af of water quality enhancement storage.

The emergency supply is for use in a natural or man-made event that causes a disruption of the normal functions of CCWD, including the electrical power, water supply, transmission, treatment, or distribution systems, and/or the CVP. Emergency events may be caused by natural disasters including but not limited to, earthquakes, floods, tornados, high winds, forest or brush fires. Emergency events may be caused by human actions including, but not limited to, civil disorder, vandalism, employee work stoppage, accidental or intentional introduction into the system of hazardous materials or chemicals, massive equipment failures, explosions or incendiary fires, or nuclear blast damage or radiation fallout.

When Delta water quality is good in wetter years, CCWD will increase diversions by about 40,000 af from the Delta for storage in LVR. Typically in fall of drier years, CCWD will reduce diversions from the Delta by about 40,000 af and rely on water stored in the LVR. Stored water will meet a portion of CCWD's water demands and will be blended with water diverted directly from the Delta to meet CCWD's water quality objectives. The effect of LVP operations will be to increase diversions from the Delta during periods of high Delta outflow and reduce diversions during low flow periods. Evaporation losses add to Delta diversions by an average of 3,300 af/yr.

Old River Intake

LVP includes operating new supplemental intake facilities in combination with those at Rock Slough. The new intake facilities will be located just south of State Route 4 on Old River (Figure 2) and will divert water from the Delta through or past a 4-million-gallon transfer facility, where the water could either be pumped to the LVR or conveyed by gravity flow to the CCC to meet demand or for blending purposes. This new intake pumping plant will include an intake structure with a fish screening system and is sized for a capacity of 250 cfs. Construction of these facilities will involve limited channel dredging and recontouring of the levee banks.

The fish protection facilities design is based on California Department of Fish and Game (DFG) criteria for fish screens in upland waters. They will

consist of a floating log boom with suspended chains to divert debris away from damaging the screens, and mechanically cleaned stainless steel fish screens, which will be installed in a concrete structure constructed within the Reclamation District 800 levee along Old River. The DFG criteria for distributed flow through the screens may require providing the intake bays with a means to control flows across the screens. Because the velocities into the intake are low and the intake and inlet channel meet hydraulic criteria for wet well pumping facilities, it is not likely that uneven flow distribution through the screens will occur. However, provisions have been made to install flow control louvers in the future to evenly distribute flow across the screens at each bay. Slots will be provided for possible future installation of a system of vertical flow louvers. The louvers, which would be installed if uneven flow distribution becomes evident in the operation of the Old River Intake and Pumping Plant facilities, would vary the headloss along the length of the screens to assure equally distributed flow through the screens throughout the range of flows to the Old River Pumping Plant. The louvers would be installed in slots that will be provided immediately downstream of the stoplog slots. These future flow louvers would be designed only as a headloss device, incapable of isolating the inlet channel bays for dewatering.

The fish protection system for the Old River intake will be a passive screen system with an approach velocity of 0.33 feet per second (fps) at lowest neap, ebb tide, elevation -2.0 feet, and a maximum screen opening of 3/32-inch, oriented vertically. The intake consists of five 15-foot-wide, 12-foot-high screened intake bays. The intake face above the screens will be an inclined concrete wall. The top of the screen opening is at mean neap, ebb tide at an elevation of -0.5 feet. The screens will be totally submerged approximately 90 percent of the time. Each bay will be screened with a series of 3 panels arranged side-by-side across the intake bay. The screen panels will consist of a series of thin, vertical wedge wires with a somewhat triangular cross section set with a 3/32-inch clear spacing. The wires will be configured such that one side of the wire faces upstream, with the point of the wire facing downstream. The vertical wedge wires will be backed by larger screen backing bars and additional supporting framework. The screen cleaning system is designed to be capable of continuous 20 minute cleaning cycles.

The following gives the design approach velocity of the screen for various levels of pumping:

Pumping Rate	250 cfs	200 cfs	150 cfs
Lowest Neap Ebb Tide	0.33 fps	0.267 fps	0.2 fps
Mean Neap Ebb Tide	0.29 fps	0.237 fps	0.17 fps

Simulations of LVP operations under the 70-year baseline hydrology using the proposed LVP operation rules and project description listed below and including current Delta operations (D-1485, with the NMFS CVP-OCAP biological opinion on winter-run chinook salmon and the Service's CVP-OCAP biological opinion on delta smelt), and assuming a delivery schedule at the current maximum CCC capacity resulted in the following estimated average rates of diversion:

	<u>Maximum Old River Pumping</u>	<u>Best Water Quality Pumping</u>
Annual Average	167 cfs	124 cfs
December-August Average	153 cfs	110 cfs -

The maximum Old River Pumping assumes the new intake is used whenever possible, while the best water quality pumping assumes water is pumped from

the intake with the best water quality. On average, the approach velocity will be below both the 0.33 fps level and the 0.2 fps level.

Proposed Operation Rules for LVP (JSA 1992):

- (1) Except as provided for below, CCWD will operate its water delivery system to meet the LVP objectives, which are to improve water quality and system reliability to the maximum extent possible on a year-round basis.
- (2) From March 15 through May 15 of each year, CCWD will divert, to the extent feasible, as much of its water requirement as possible, consistent with applicable permits and licenses, at the screened Old River intake.
- (3) Except as described in rules 4, 5, and 6 below, CCWD will fill the LVR either by re-diverting CVP water rights contractual water to storage or by diverting surplus water under Application 20245 whenever the water quality goals of the project can be satisfied with the storage of that water.
- (4) CCWD will not divert water to storage in LVR from March 15 through May 31 except when reservoir storage is below emergency storage levels. For the purposes of this rule, the term "emergency storage" will mean at least 70,000 af in storage in below normal years, above normal years, and wet years and 44,000 af in dry years and critical years. Year types will be as defined in the February edition of the California Department of Water Resources (DWR) Bulletin 120 and the Four Basin Index defined by D-1485.
- (5) During April 1-30, CCWD will avoid diversions from the Delta and will instead release up to 12,500 af of water (equivalent to CCWD's projected critical-year buildout demands in April) from the LVR to meet demands in the CCWD service area. These releases will occur only if storage in the reservoir is above emergency storage levels and will continue until reservoir emergency storage levels (70,000 af in wet, above normal, and below normal years and 44,000 af in dry and critical years) are reached. When emergency storage levels are reached, CCWD will, without limitation, be able to continue or initiate diversions from the Delta for direct use within the CCWD service area.
- (6) If DFG, the Service, and NMFS mutually agree that a change in the periods described in rules 4 or 5 is desirable, then they will, no later than February 15 of any year, provide Reclamation and CCWD with a written request to modify the operational rules enumerated as rules 4 and 5 above. Operations will be modified only after Reclamation and CCWD provide written concurrence with the agencies' request. In no event will operational modifications made between March 15 and May 15 involve ceasing diversion for more than 30 days, although such cessation of diversion will not be for consecutive periods of less than 7 days. The emergency storage level limitations set forth in rule 4 above will be fully applicable to and will limit the operation of this rule.
- (7) These operational rules will not become effective until the LVR is initially filled to a storage level of 90,000 af.

Figure 3 illustrates the storage allocations within LVR with implementation of these rules of operation.

In order to meet water quality goals, the operations of the LVP require that the reservoir contain only high quality water. In order for high quality water to be available in Old River, salinity intrusion in the Delta must be low; for the water quality goals to be met, diversion of high quality water in Old River requires that the salinity at Collinsville be about 2 ppt or less. Thus, when water is diverted to the reservoir, the 2 ppt isohaline will be in the vicinity of Collinsville or further west.

D-1485 was designed to provide protection to Delta agricultural, fisheries, municipal and industrial users, and Suisun Marsh resources. Some of the provisions of D-1485 issued in 1978 by the SWRCB provide water quality and flow requirements under which Reclamation and CCWD operate and define baseline conditions. In addition to D-1485, operating requirements are determined by agreements between project operators, such as the Coordinated Operations Agreement between Reclamation and DWR, the Operations and Maintenance agreement between Reclamation and CCWD, and those of other parties such as the 4-Pumps Fish Mitigation Agreement between the DFG and the DWR.

The following table shows the simulated CCWD diversions from the Delta over the 70-year baseline with LVP based on D-1485, CVP-OCAP biological opinion for NMFS and Service (1993) and the CCWD deliveries to service area at maximum of 148,000 af/yr modeled over the 70-year baseline (1922-1991):

Table 1. Average, Maximum, and Minimum CCWD Diversions with LVP Based on the Proposed Action and CCWD Deliveries to Service Area at 148,000 AF/YR Modeled Over a 70-Year Baseline (1922-1991) (CCWD 1993)

Total CCWD Diversions (TAF) with LVP (Modeled Over 70-Year Baseline)													
	<u>Oct</u>	<u>Nov</u>	<u>Dec</u>	<u>Jan</u>	<u>Feb</u>	<u>Mar</u>	<u>Apr</u>	<u>May</u>	<u>Jun</u>	<u>Jul</u>	<u>Aug</u>	<u>Sep</u>	<u>Total</u>
Ave	16.0	10.1	9.0	6.9	5.4	6.7	1.2	11.1	16.0	17.8	17.7	21.2	139.1
Max	24.4	21.9	20.5	18.5	14.2	11.8	9.8	13.6	27.3	29.9	27.8	26.4	166.5
Min	1.7	1.8	2.0	2.0	1.1	1.9	0.0	6.2	7.7	16.7	6.2	3.8	101.6
CCWD Deliveries to Service Area at 148,000 AF (Modeled Over 70-Year Baseline)													
Ave	12.3	10.1	8.5	7.0	5.7	6.6	6.7	12.7	15.1	17.7	18.5	14.6	135.6
Max	13.6	10.6	10.1	8.1	8.3	11.2	9.8	13.6	15.4	18.3	19.2	15.3	148.0
Min	12.1	10.0	8.2	6.9	5.3	5.6	6.0	12.5	13.7	17.6	15.5	14.5	133.2

Table 1 shows that the maximum simulated diversion rate over the 70 years is about 166,000 af for a water year. The minimum is about 102,000 af for a water year. Table 1 shows service area deliveries for the same conditions with the delivery schedule assumes the current estimated maximum canal capacity of 148,000 af with average deliveries of about 135,000 af. The deliveries vary from 133,000 to 148,000 af in critical years.

Some of the changes to existing flow and salinity requirements incorporated in the February 12, 1993, long-term CVP-OCAP biological opinion for winter-run chinook salmon would affect operation of LVP (NMFS 1993). Consultation on the effects of the long-term operations of CVP-OCAP on delta smelt is currently in progress.

Species Account/Environmental Baseline

Please refer to the final rule to list the delta smelt as a threatened species (58 FR 12854), and the May 26, 1993, CVP-OCAP biological opinion for delta smelt (Case No. 1-1-93-F-32) for additional information on the biology and ecology of this species.

Species Account

Factors important with LVP are:

- (1) The positioning of the entrapment zone (EZ) below the confluence of the Sacramento and San Joaquin Rivers seems to lead to the highest delta smelt populations (Moyle *et al.* 1992). This finding supports the premise that the salinity gradient most approximating historical conditions favors the delta smelt population.
- (2) During periods of drought and/or increased water diversions, the EZ and associated rearing smelt are shifted farther upstream in the Delta. When located upstream, the EZ becomes confined to the deep river channels, becomes smaller in total surface area, has swifter, more turbulent water currents, lacks the proper geographic distribution (*i.e.*, habitat availability and dispersal capability) to specific conductance relationship for delta smelt, and lacks high zooplankton biomass. In addition, riverine areas expose rearing delta smelt to agricultural diversions, higher levels of contaminants, and unsuitable salinity regimes (Moyle *et al.* 1992).
- (3) Delta smelt have a low fecundity relative to other species of Osmeridae. Most spawning occurs from January to July. Disturbance of substrates and changes in water quality during egg maturation may result in egg mortality. Current sampling has not been widespread enough to indicate the relative importance of spawning areas. Each of the sites where delta smelt are known to spawn are subject to high levels of diversion. After the larvae hatch, they move downstream into eastern Suisun Bay where conditions of microzooplankton density, salinity, and geographic distribution are suitable for rearing. The delta smelt remain in this area until upstream migration of the adult spawners to backwater sloughs and channel edges of the Delta.
- (4) Delta smelt face threats that operate on a scale of one or two of its generations: the species' 1-year life span renders it susceptible to rapid short-term population declines and the threat of extinction with the failure of a single reproductive season. The delta smelt could become extinct if spawning failures occur in two successive years.

Environmental Baseline

CVP effects including those of existing CCWD operations are considered part of the existing environmental baseline and were addressed the 1993 CVP-OCAP consultation on delta smelt (USFWS 1993) for 1993. The biological assessment for long-term CVP-OCAP is currently being prepared and will address the effects of CVP future operations. Because of the nature of the proposed actions, this biological opinion and the incidental take statement address all CCWD-related diversions, including the LVP.

The following is a summary of the environmental baseline for delta smelt within the Sacramento-San Joaquin delta. For more information, refer to USFWS (1993).

Export Pumping: During periods of high export pumping and low to moderate river outflows, reaches of the San Joaquin River reverse direction and flow upstream to the pumping plants located in the southern Delta. The State operated Banks pumping plant presently exports water at rates up to 6,400 cfs. At times, an additional 3,900 cfs are pumped through use of four newly installed pumps. Pumping from Barker Slough, a delta smelt spawning area, through the North Bay Aqueduct has averaged at least 36,000 af in 1990 and

1991 (about 50 cfs). The Federal Tracy pumping plant can export water at rates up to 4,600 cfs. In addition, local private water right holders divert 3,000-4,000 cfs from about 1,800 diversions located throughout the Delta.

Reverse Flows and Entrainment: When total diversion rates are high relative to Delta inflow and the lower San Joaquin River and other channels have a net upstream (i.e., reverse or negative) flow, out-migrating larval and juvenile fish of many species become entrained in this water and displaced. Large mortalities occur as a result of entrainment and predation by striped bass and other species at the various pumping plants and other water diversion sites. Net positive riverine flows, and estuarine outflows of sufficient magnitude are required for delta smelt larvae to be carried downstream to near the upper end of the EZ. Suitable rearing habitat is between the western part of Honker Bay and the confluence of the Sacramento and San Joaquin Rivers, outside the influence of the pumping plants. In recent years, the number of days of reversed San Joaquin River flow have increased, particularly during the January-July spawning months for delta smelt (Moyle *et al.* 1992). All size classes of delta smelt are lost from the estuary when they are entrained by the pumping plants and diversions in the south Delta (D. Sweetnam, DFG, pers. comm.). Average numbers of delta smelt salvaged at the State fish screen from 1980 to 1992, are as follows:

<u>April</u>	<u>May</u>	<u>June</u>	<u>July</u>	<u>August</u>
676	1,413	7,884	4,309	1,041

These numbers are multiplied by a factor of approximately 6-10 to account for effects of predation, screen efficiency, handling, and trucking losses, as follows (x10):

<u>April</u>	<u>May</u>	<u>June</u>	<u>July</u>	<u>August</u>
6,760	14,130	78,840	43,090	10,410

The following table gives information on salvage for splittail, longfin smelt, and delta smelt for 1993:

Table 2. Preliminary January through August 1993 salvage estimates for Sacramento splittail, longfin smelt, delta smelt complete to June 27, 1993.

<u>January 1993</u>	<u>CVP</u>	<u>SWP</u>
Sacramento Splittail	11,412	25,727
Longfin Smelt	0	12
Delta Smelt	0	3,086
<u>February 1993</u>		
Sacramento Splittail	2,652	5,991
Longfin Smelt	0	0
Delta Smelt	36	1,154
<u>March 1993</u>		
Sacramento Splittail	1,764	285
Longfin Smelt	0	0
Delta Smelt	60	85
<u>April 1993</u>		
Sacramento Splittail	1,668	222
Longfin Smelt	0	8
Delta Smelt	0	0
<u>May 1993</u>		
Sacramento Splittail	52,932	16,847
Longfin Smelt	132	206
Delta Smelt	768	15,901
<u>June 1993</u>		
Sacramento Splittail	52,344	7,146
Longfin Smelt	0	0
Delta Smelt	2,400	6,187
<u>July 1993</u>		
Sacramento Splittail	9,396	1,610
Longfin Smelt	0	240
Delta Smelt	240	827
<u>August 1993</u>		
Sacramento Splittail	60	342
Longfin Smelt	0	32
Delta Smelt	0	24

These numbers would be multiplied by 6-10 to estimate losses from predation, screening and handling (Sweetnam, DFG, pers. comm.).

Fish Screens: Fish screens currently in use at Delta intakes may not protect delta smelt from being entrained or impinged. The current DFG requirement for screening salmon of 0.33 fps approach velocity and 3/32-inch opening may not be adequate to protect delta smelt depending on lifestage and size. Ongoing studies may result in a new recommended approach velocity. The Service recommends a 0.2 fps approach velocity with a 3/32-inch opening as a conservative estimate based on shad.

Delta Outflow and the Entrapment Zone: Adequate outflows from February 1 to August 31 are needed to maintain the placement of the EZ during the critical rearing interval for delta smelt. In recent drought years, on the average, exports, diversions, and hydrologic conditions have limited net daily delta outflow to about 3,500 cfs during this interval (D. Sweetnam, DFG, pers. comm.).

Table 3. Relationship of Delta Outflow to EZ Position from the Golden Gate Bridge (km) in Various Year Types (Taken from Figure 4):

Delta Outflow (cfs)	EZ Position (km)
3,500	92-106
9,000	73-85
15,000	67-78
20,000	65-73
30,000	60-68

Figure 5 shows the 62, 72, 82, 92, and 102 km distances from the Golden Gate Bridge in the Sacramento-San Joaquin Delta. An outflow of 3,500 cfs would place the eastern edge of the EZ near Isleton on the Sacramento River and Santa Clara Shoal on the San Joaquin River (Figures 4 and 5). This species' embryonic, larval, and postlarval mortality rates will probably become higher if continued reduced western Delta outflow allow increases in the salinity level and relocation of the EZ upstream into the river channels.

Dredging: Channel dredging is currently done by many Federal and State agencies, and private entities in Delta waterways. This dredging may affect delta smelt adults, juveniles, and larvae by destroying spawning habitat and mobilizing sediments that interfere with movement and may contain contaminants such as mercury and tributyltin.

Effects of the Proposed Action

Evaluation of existing effects is based on simulation of existing conditions through use of the DWRSIM operations model, the Fischer model, and the JSA delta smelt model. This modeling enables comparisons between alternative water project operations. There are several assumptions made in the JSA delta smelt model, including: (1) the total population of delta smelt is 500,000 adults; (2) half of the total population spawns on the Sacramento side of the delta and half spawns on the San Joaquin side of the Delta; (3) the delta smelt spawning on each side of the Delta are uniformly distributed. Ongoing

studies and monitoring by DFG and the Interagency Ecological Study Program reveal large-scale seasonal and annual variations in distribution and abundance that suggest these assumptions may not represent "typical" conditions. These limitations indicate that modeling may be an appropriate tool for identifying relative trends but not for quantifying impacts.

Los Vaqueros Reservoir

CCWD water project operations, with and without LVP, affect abundance of delta smelt (Jones and Stokes 1992). Survival of delta smelt and the availability of habitat depends on the location of primary rearing habitat (i.e. EZ), flow patterns in the Delta, and the proportion of flow diverted. Variables that have been modeled to evaluate effects on delta smelt with and without LVP include lower San Joaquin River net flow, Delta inflow, Delta outflow, total dissolved solids, and SWP, CVP, and CCWD diversions from the Delta.

Table 4. Under the proposed action, LVP with the proposed operation rules would result in the following increases or decreases in diversions during April through August relative to a 70-year baseline for proposed operations:

<u>Month</u>	<u>Number of Increases or Decreases in Monthly Diversions over a 70-Year Baseline</u>	
	<u>Years</u>	
April	0	increases (0 percent)
	60	decreases (86 percent)
	10	no change (14 percent)
May	0	increases (0 percent)
	18	decreases (26 percent)
	52	no change (74 percent)
June	18	increases (26 percent)
	18	decreases (26 percent)
	34	no change (48 percent)
July	1	increase (1.4 percent)
	5	decreases (7 percent)
	64	no change (91 percent)
August	1	increase (1.4 percent)
	9	decreases (13 percent)
	60	no change (86 percent)

Table 4 shows changes with the Los Vaqueros Project with the project rules and description under current Delta operations, D-1485 and the current winter-run long-term CVP-OCAP biological opinion and the 1993 delta smelt CVP-OCAP biological opinion. June would be the primary month that diversions for LVP would be higher than other months, causing possible adverse effects if delta smelt are present. Reasonable and prudent measure number 1 resolves this issue. The goal in April is elimination of diversions to benefit winter-run chinook salmon and other estuarine fish.

Over a modeled 70-year period during the rearing months of June, July, and August, simulated LVP diversions in June would increase in 18 years of the modeled 70-year period (26 percent increase). Under the proposed action, the

number of increased diversions in the rearing months of June, July and August would be 20 out of 210 months (10%). This could result in increased juvenile and larval losses during this interval caused by entrainment at the intake and the upstream displacement of rearing habitat into inferior areas upstream of the confluence of the Sacramento and San Joaquin Rivers. Inspection of Table 5 indicates a small increase in the amount of diverted water, which suggests that entrainment effects on delta smelt would be small.

The first time filling of LVR would result in an increase in diversion by 90,000 af from the Delta. This would cause a large increase in delta smelt losses if done in one year, and probably fewer losses if done over several years depending on water year type. The volume diverted would be limited by the availability and quality of water and the capacity of the pumping plant to fill the reservoir at 200 cfs, or about 12,000 af/month. The water quality goals for LVP require low levels of salinity intrusion during filling, and the 2 ppt isohaline will be in the vicinity of Collinsville or further west during the initial filling operations. The majority of these additional diversions will take place during the upstream migration, spawning, and rearing interval of December through August for delta smelt. Although effects of this first time filling have not been modeled, losses of adults, juvenile, and larval fish would occur during this interval. Restrictions under the Incidental Take section below are designed to limit impacts to a minor level.

The proposed operation rules for LVP, as listed in the Description of the Proposed Action, allow diversions from the Delta from March 15 to May 15 to fill LVR when the reservoir is below emergency storage levels. The delta smelt spawning interval is from January through July with a two month spawning peak. A 30-day cessation in all CCWD diversions that may encompass different parts of the March 15 to May 15 diversion interval has been listed as part of the proposed operation rules for LVP to protect delta smelt. This would not adequately address entrainment of adults, juveniles, and larvae during the 60-day peak spawning interval. Reasonable and prudent measure number 1 resolves this issue.

The following table shows existing Delta outflow and changes due to LVP by water-year type:

Table 5. Existing Delta Outflow and Outflow Changes by Water-Year Type (AN=Above Normal Water-Year Type; BN=Below Normal Water-Year Type)
Existing Delta Outflow (cfs)

	February	March	April	May	June	
Wet	91,377	58,121	55,111	42,358	24,182	
AN	42,111	41,797	18,978	19,560	13,122	
BN	25,413	18,313	8,790	9,901	7,762	
Dry	18,348	7,277	7,975	7,140	5,793	
Critical	5,789	4,937	5,510	4,658	3,848	
Change in Outflow with Project (cfs)						
Wet	12	-16	78	0	0	Average 15
AN	65	-37	37	17	0	16
BN	-51	-18	19	5	0	-6
Dry	-10	-2	12	0	0	0
Critical	-3	0	0	0	0	1

Table 5 shows the simulated outflow by water year type for existing conditions and changes in simulated outflow that would result with LVP under D-1485 Delta standards. Changes in Delta outflow with the LVP would be small relative to total Delta outflow. The largest decreases in outflow would occur in February and March with LVP (JSA 1992), generally less than 1 percent of total Delta outflow. Reduced outflow is more frequent but proportionally smaller during wetter years. Changes under the proposed action with LVR, as in Table 4 are equally small. Reduced outflow during March through June could worsen conditions that delay larval movement to suitable rearing areas in eastern Suisun Bay, but if Delta diversions cease through deliveries to the service area for LVR, then conditions would improve. Reduced outflow also would contribute to conditions that shift the EZ upstream towards the Delta during the larval and juvenile rearing period in March. The effect of outflow changes attributable to LVP on the EZ location and delta smelt rearing habitat would vary depending primarily on net Delta outflow. Daily and monthly tidal effects significantly shift the location of the EZ, thus varying the magnitude of effects on delta smelt. A spring, high tide would displace the EZ further upstream and thus would increase the adverse effects of diversions on rearing delta smelt. Conservation measures agreed to herein indicate that any upstream shift will be sufficiently small to suggest that consequent effects on delta smelt will be small. These effects are resolved through reasonable and prudent measure number 1.

The modeled data provided to the Service in an August 9, 1993, FAX from CCWD shows that an effect of the LVP is to shift the highest diversions from critically dry years to wet years and minimum diversions from wet years to dry years. The data set shows that while diversions in any period may increase a small amount, the overall effect of the LVP is not to increase net diversions, except for a small amount to replace reservoir evaporation. Fourteen years (20 percent) show increased diversions above 148,000 af and nineteen years (27 percent) show decreases in diversions below the normal year delivery level of 135,000 af. During dry and critical years, CCWD is maintaining operational flexibility in reduction of its diversion of CVP water and CCWD may or may not reduce its diversion of CVP water. The adverse impacts of diversions during this period when delta smelt may be diverted are resolved through reasonable and prudent measure number 1. CVP water not used by CCWD would be available to Reclamation for allocation to other uses.

The following table shows simulated annual entrainment occurring at CCWD diversions ranging from 750 to 16,000 adult equivalents depending on water year type and the assumptions associated with the simulation (Jones and Stokes Assoc. 1992):

Table 6. Modeled Average Annual Entrainment Losses of Delta Smelt Adult-Equivalents by Water-Year Type (Analysis Assumes Delta Smelt Population of 500,000 Adult Fish) (Jones and Stokes 1992)

Water-Year Type	Total Delta Losses	CCWD Existing Losses	Change With LVP	(Percent)
Wet	34,000	750	20	(2.7)
Above Normal	67,000	3,200	600	(18.8)
Below Normal	120,000	5,200	600	(11.5)
Dry	120,000	8,300	350	(4.2)
Critical	110,000	16,000	<1,000>	(6.2)

There are several assumptions made with the JSA modeling that have not been validated, thus making the modeled data more qualitative than quantitative. The increased losses with LVP result from increased diversions in February and March. Simulated losses to all Delta diversions totaled 34,000 adult equivalents during wet years to 120,000 during dry years (Jones and Stokes 1992). At high levels of pumping, large numbers of delta smelt seasonally appear at the Federal and State fish protection facilities. These numbers vary widely depending on the season, the level of exports, Delta inflow, Delta flow patterns, and the presence of adults and larvae in the lower Sacramento-San Joaquin Rivers.

Table 6 shows the modeled average annual entrainment losses of delta smelt by water year type for CCWD and changes with LVP using average annual deliveries of 135,000 af. Simulated existing entrainment losses at CCWD pumps are estimated to increase total Delta entrainment losses by 2.2% to 14.5%, depending on water year type. Using Table 6 and assuming no April diversion from the Delta under the LVP operations rules and delta smelt spawning from February through June, simulated changes in entrainment losses could range from an increase of 0.9 percent in normal years to a decrease of 1 percent in critical years. These percentages assume a total delta smelt population of 500,000 adult fish and losses would be proportionately higher if the total population number is assumed to be lower. Sweetnam (DFG, pers. comm.) has estimated a total delta smelt population as low as 180,000 adults, which would result in modeled entrainment losses of 67 percent, in a dry year, while JSA has estimated total population of 500,000 adults with modeled entrainment losses of 24 percent in a dry year (D. Sweetnam, DFG, pers. comm.; JSA 1992). The greatest losses of delta smelt due to LVP result from entrainment. Addition of the Old River intake and implementation of reasonable and prudent measure number 2 are expected to result in a net decrease in level of entrainment compared with existing conditions. Table 6 reflects the effects of use of the Old River intake as the point of diversion.

Figure 6 shows the proportional average annual impact to delta smelt simulated for the existing Delta diversions and CCWD with LVP and D-1485. The State Banks and Federal Tracy Pumping Plants account for 74.3 percent of the modeled losses to diversion while agricultural diversions account for 24.1 percent. Existing CCWD with LVP account for an additional 1.6 percent of total model losses.

Figure 7 shows the simulated 12-month sum of diversions with LVP graphically, with a maximum of about 185,000 af and a minimum of about 90,000 af. The graph demonstrates that high diversion periods follow low diversion periods, when the reservoir is used for water quality blending. Figure 8 shows this modeled information with LVP on a monthly basis so that deliveries may be compared with diversions. In the modeled 70-year baseline period, February, April, May, and August have diversions that are less than the deliveries to the service area. This indicates deliveries use LVP water which would decrease losses of delta smelt due to diversions as verified in Table 6.

Old River Intake

Construction of the Old River intake will involve dredging the area immediately in front of and adjacent to the intake structure in Old River. This dredging may remove delta smelt spawning habitat and will mobilize sediments that could effect movement of adult, juvenile, and larval delta smelt. The sediments also may contain contaminants, such as mercury and tributyltin, that affect adult, juvenile, or larval fish directly, or may affect the planktonic organisms that delta smelt use for food. Maintenance and repair operations may cause many of these same effects. These impacts are resolved through reasonable and prudent measure number 3.

The planned screen cleaning interval of 20 minutes at the new Old River intake may be sufficient to maintain an approach velocity of 0.33 fps, or recommended velocity of 0.20 fps. Excessive debris build-up would result in larvae greater than 21 mm, juveniles, and adult delta smelt being entrained or impinged due to inadequate screen openings and approach velocities. The design approach velocity is a maximum value which would occur for a short period at lowest neap ebb tide (-2.0 feet) with all five pumps operating. In the event of screen clogging, a hydraulic head differential would be sensed electronically and screen cleaning initiated to maintain the design approach velocity. Continuous head differential across the screen will be alarmed and operators could shut down pumping units until the differential clears. Multiple screen cleaning devices may be required if the planned cleaning interval of 20 minutes cannot be achieved. This issue is resolved in reasonable and prudent measure number 2.

The location of the Old River intake will decrease losses of delta smelt compared with the existing Rock Slough intake. This is because the new intake is located on a flowing river that allows escapement. The Rock Slough intake is at the end of a backwater slough and fish cannot escape the effects of the pumping.

Summary of Project Effects

The following operations of the LVP will have an adverse effect on delta smelt adults, juveniles, and larvae:

- (1) At certain times of the year, modifications of flow patterns on the San Joaquin side of the Delta, due to filling operation of LVP, likely will result in small increases in the losses of adults, juveniles, and/or larval delta smelt through displacement to areas less suitable for spawning or rearing.
- (2) Modifications in the operations at Rock Slough under LVP will reduce but not eliminate the loss by entrainment of adults, juveniles, and/or larval delta smelt.
- (3) During filling operations, decreases in Delta outflows likely will result in low levels of interference with larval movement to suitable rearing habitat and result in losses of juveniles and larvae.
- (4) Construction of the new Los Vaqueros intake on Old River likely will result in a minor level of harassment or harm to individual adults, juveniles, and/or larvae and destroy less than 1 acre of spawning habitat.
- (5) Adults, juveniles, and/or larval fish likely will be entrained or impinged at the Los Vaqueros intake on Old River and otherwise taken in the reservoirs, pipelines, and other facilities comprising LVP. The location of the new intake will decrease entrainment losses of delta smelt adults, juveniles, and/or larval fish compared with the existing Rock Slough intake.
- (6) Adults, juveniles, and/or larval fish likely will be harmed or harassed during maintenance and repair operations at the new Los Vaqueros intake on Old River.

Cumulative Effects

Cumulative effects include the effects future State, local, or private actions affecting listed species that are reasonably certain to occur in the area

considered in this biological opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the Act.

Cumulative effects on the delta smelt include any future diversion of water that may entrain adults or larvae or that may decrease outflows incrementally and cause a shift in the position of the entrapment zone. Water diversion from numerous small agricultural and duck club intakes in the Delta and Suisun Marsh, and upstream of the Delta may be cumulative effects.

Another component to decreasing outflows is salt water intrusion, which allows incursion of competing organisms, such as asian clam, to extend their ranges and increase their populations. These organisms compete with delta smelt for food microorganisms.

Other cumulative effects include chemical contamination from point and non-point discharges that may adversely affect survival rates and reproductive success. Pesticides, herbicides and selenium all have been implicated as potential sources of mortality for delta smelt.

We find that the environmental baseline, effects of this project, and cumulative effects, when taken together, do not appreciably decrease the likelihood of survival and recovery of the delta smelt because the environmental baseline is largely addressed in the other consultations (CVP-OCAP, Ref. No. 1-1-93-F-32, and EPA Water Quality Standards, Ref. No. 1-1-93-F-61) and the proposed mitigation adequately offsets the effects of the proposed project. At this time, we have no compelling information that would suggest that cumulative effects, by themselves, would jeopardize the continued existence of the delta smelt.

Incidental Take

Sections 4(d) and 9 of the Act, as amended, prohibit taking (harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or attempt to engage in any such conduct) of listed species of fish or wildlife without a special exemption. Harm is further defined to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing behavioral patterns such as breeding, feeding, or sheltering. Harass is defined as actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding or sheltering. Under the terms of §7(b)(4) and §7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered a prohibited taking provided that such taking is in compliance with the terms and conditions of this incidental take statement. The measures described below are nondiscretionary, and must be implemented by the agency so that they become binding conditions of any grant or permit issued to the applicant, as appropriate, in order for the exemption in §7(o)(2) to apply. The Federal agency has a continuing duty to regulate the activity that is covered by this incidental take statement. If the agency fails to require the applicant to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the permit or grant document, the protective coverage of §7(o)(2) may lapse.

Spawning adults, juveniles, and larval delta smelt are present in the lower Delta from January through August. During this interval, periodic high outflows flush larvae and juveniles to suitable rearing habitat in eastern Suisun Bay. For the purposes of this Incidental Take Section, the term "larvae" concerns only larvae longer than 21 mm.

The Service anticipates implementation of the actions above would result in an indeterminable level of incidental take of delta smelt associated with delivery of an annual maximum of 148,000 af of water.

Reclamation and CCWD are authorized to take all delta smelt entrained as a result of operations of LVP with annual maximum 148,000 af delivery. This authorized take includes but is not limited to fish entrained at the Rock Slough intake, Mallard Slough intake, and Old River intake and all diversions not included within the proposed actions.

The Service establishes the following reasonable and prudent measures to minimize the impact of incidental take. The measures below are nondiscretionary and must be undertaken by Reclamation and CCWD.

- (1) CCWD diversions shall minimize take of delta smelt adults, juveniles, and larvae.
- (2) Entrainment losses of delta smelt shall be reduced through screening of the Rock Slough and Old River intakes and through adequate screen cleaning.
- (3)
 - (a) Losses and harassment of adult, juvenile, and larval delta smelt shall be reduced during the construction, maintenance, and repair operations of the Old River intake through use of a work window or implementation of Best Management Practices.
 - (b) Losses to upstream migrating adults and downstream migrating juveniles and larvae shall be minimized through use of the Old River diversion. The location of this intake in Old River will decrease the numbers of delta smelt lost to diversion compared with losses that have occurred at the Rock Slough intake.

To be exempt from the prohibitions of section 9 of the Act, the following terms and conditions, which implement the reasonable and prudent measures described above, must be included in any Federal authorization or funding for the project. Compliance with these measures is mandatory; all notices, plans, and other documents required below shall be prepared and implemented with the prior review and approval of the Service.

- (1) The following terms and conditions implement reasonable and prudent measure (1):
 - (a) Diversions to fill LVR shall be timed to avoid or reduce effects on the Delta smelt population.
 - i) Filling of the reservoir shall be unrestricted when the 14-day running average of the 2 ppt isohaline is centered at Chipps Island or further west from February through May; filling shall be unrestricted when the 14-day running average of the 2 ppt isohaline is centered at Collinsville or further west in January and June through August; filling shall be unrestricted in the months of September through November, with Reclamation making the necessary upstream releases to make water available. If real-time monitoring indicates delta smelt adults are not present at the point of diversion in December, then filling shall be unrestricted in December, with Reclamation making the necessary upstream releases to make water available; if real time monitoring indicates delta smelt adults are present at the intake in December, filling shall be unrestricted if the 2 ppt isohaline is centered at or further west of Collinsville.

- ii) During the initial reservoir filling and when the reservoir is below emergency storage levels, defined as 44,000 af in dry and critical years and 70,000 af in below normal, above normal and wet years, per operational rule 4, or following a release for an emergency as defined in the project description, CCWD may fill the reservoir without the above restrictions. This filling may occur if 1) CCWD has provided the Service with notification of the emergency release, describing the nature of the emergency and the amount of the release(s) and 2) CCWD notifies the Service of the intent to fill when filling would otherwise be restricted and the Service determines the filling can occur without exposing the species to an unacceptable level of risk. At the proposed time of first time filling, the Service will reassess the status of the delta smelt to determine whether the relative species abundance is high enough to withstand additional levels of take and whether filling can occur without exposing the species to an unacceptable level of risk. The projected date of first time filling and a schedule for filling shall be submitted to the Service and filling initiated only on approval from the Service.
- (b) CCWD shall submit to DFG, NMFS, and the Service, per Operation Rule 6, by January 1 of each year a proposal for implementing operational rules 4, 5 and 6. This group will notify CCWD and Reclamation, if necessary, to change the timing of the periods totaling 75 days when reservoir filling is to be avoided and the concurrent 30 days when all diversions are to be avoided. The periods shall consist of a 30-day period and a 45-day period with no reservoir filling that shall be between January 1 through July 31, and a concurrent period of 30-days with no diversions, to a maximum of 12,500 af.
- (c) A study plan shall be submitted to the Service for approval within 90 days of the issuance of this opinion to determine the presence of delta smelt adults, juveniles, and larvae at the Rock Slough intake and in the area where the new Old River intake will be constructed. Funding for the ongoing Interagency Ecological Studies Program shall be provided by CCWD to develop capability for real time monitoring and instantaneous abundance index calculation for these two intake sites. This study shall begin within four months after approval of the plan by the Service and shall continue until LVP is operational. A summary of the results of this study shall be transmitted to the Service at the end of each calendar year. The study plan shall include a methodology for determining estimates of entrainment losses. Fish sampling techniques and handling procedures shall be done so that fish mortality is minimized.
- (d) During the interval January 1 through August 31, real time monitoring to calculate an index of abundance for delta smelt adults, juveniles, and larvae vulnerable to entrainment shall be conducted at all current and future CCWD intakes. Sampling shall be done in close proximity from the intake and in the channel or bay nearby. This monitoring also shall include water quality monitoring, including monthly measured total dissolved solids, and daily measured electrical conductivity, temperature, and flow. Monthly samples shall be measured one meter below the water surface and one meter above the bottom. A summary of the calculated indices from the real time monitoring for adults, juveniles, and larvae present near CCWD intakes, and water quality data shall be

transmitted at the beginning and middle of each month to the Sacramento Field Office at 916-978-4619.

- (e) The above real time monitoring information will be used by CCWD to determine diversion of water at the Rock Slough, Old River, and Mallard Slough intakes. The intent is to minimize take of delta smelt adults, juveniles, or larvae during the spawning and rearing interval of January 1 through August 31 that are exposed to pumping/diversion related losses. Notification of proposed point of diversion to reduce take of delta smelt shall be submitted to the Service for approval and included in the twice monthly report mentioned above (1.d).
 - (f) An annual summary of all collected information shall be submitted to the Service at the end of each calendar year.
- (2) The following terms and conditions implement reasonable and prudent measure (2):
- a) CCWD shall collaborate with Reclamation to ensure that screening the intake at Rock Slough in accordance with the CVPIA is completed by October, 1998. Screens with a 3/32" vertical slotted opening and an average approach velocity of 0.2 cfs (or new delta smelt criteria) and with screen cleaning capability that assures these criteria are met and that are effective for delta smelt greater than 21 mm length shall be put in place immediately upon approval by the Service of the mesh size, approach velocity, and screen cleaning criteria to be used. At least 90 days before the screened diversion becoming operational, an assessment of the ability of the screen cleaning to maintain the above approach velocity and openings shall be submitted to the Service.
 - b) The screened diversion at Old River shall be constructed prior to any operation of the Old River Intake and not later than January, 1997. The screen design shall include the capability of operating the screen cleaning to maintain approach velocities of an average of 0.2 cfs with a 3/32" opening (or new delta smelt criteria). At least 90 days before the screened diversion at Old River becomes operational, an assessment of the ability of the screen cleaning to maintain the above approach velocities and openings shall be submitted to the Service. Additional screen cleaning capability shall be required if the cleaning levels are not adequate.
- (3) The following terms and conditions implement reasonable and prudent measure (3):
- (a) Construction, maintenance, and repair operations of the Old River intake shall take place from September 1 through December 30. When possible, best management practices shall be used to minimize sediment disturbance. Delta smelt spawning habitat lost due to construction of the intake and other structures including submerged substrates such as rocks, gravel, tree roots, branches, and aquatic plants shall be created, or acquired and enhanced, and maintained in perpetuity at a ratio of 3:1. A plan that outlines the above best management practices and spawning habitat replacement shall be submitted to the Service for approval within 180-days of issuance of this opinion.

- (b) Starting not later than March, 1997, all CCWD diversions of CVP water shall (see terms and condition 1.e above) take place at the Old River diversion from January 1 through August 31. An adequately screened Mallard Slough intake may be used when water quality is acceptable, typically less than 0.2 ppt, so that the 2 ppt isohaline is well to the west of Chipps Island.

Figure 9 depicts how implementation of the above project description and reasonable and prudent measures will affect the timing of diversion of water in the Delta.

Reporting Requirements: Reclamation shall require all contractors, and CCWD operation personnel to report immediately any information about take or suspected take of delta smelt. Reclamation shall immediately notify the Service within 1 working day of any such information. Notification must include the date, time, and precise location of the incident/specimen, and any other pertinent information. The Service contact persons are Robert Pine and Matt Vandenberg at 916-978-4613 and 916-978-4866, respectively. Any killed specimens that have been taken shall be properly preserved in accordance with Natural History Museum of Los Angeles County policy of assessment (10% formalin in quart jar or freezing). Information concerning the circumstances of the taking, the time interval between death and preservation, the water temperature and outflow/tide conditions, and any other relevant information shall be written on 100% rag content paper and included in the container with the specimen. Preserved specimens shall be delivered to the Service's Division of Law Enforcement at 2800 Cottage Way, Sacramento, California 95825-1846 (916-978-4861).

This concludes formal consultation on the proposed construction and operation of LVP. Reinitiation of formal consultation is required if (1) the amount or extent of incidental take is exceeded, as previously described, (2) the provisions and requirements under the Reasonable and Prudent Measures are not implemented, (3) new information reveals effects of the proposed construction and operation that may affect listed species or critical habitat in a manner or to an extent that was not considered in this opinion, (4) commitments and time lines described in the Description of the Proposed Action to offset and avoid project related impacts are not met or adhered to, (5) a new species is listed or critical habitat is designated that may be affected by the action, and/or (6) the status of the population (distribution and abundance) of delta smelt deteriorates prior to initiation of project construction to a point where, in the Service's view, the proposed action would result in jeopardy.

If you have any questions regarding this opinion, please contact Robert Pine at the Sacramento Field Office at 916-978-4866 for further discussion.

Richard L. Jachowski

Richard L. Jachowski

cc: ARD-ES, Portland, OR
D. Sweetnam, DFG, Stockton, CA
Reclamation Projects Branch, SFO
Wetlands Branch, SFO
Chief, Endangered Species Division, Arlington, VA

Literature Cited

- Jones and Stokes Ass. 1992. Biological assessment for Federal threatened endangered, and candidate species for the Los Vaqueros Project. 240 pages plus Appendices and Figures.
- Moyle, P. B., B. Herbold, D. E. Stevens, and L. W. Miller 1992. Life history and status of delta smelt in the Sacramento-San Joaquin Estuary, California. Trans. Am. Fish. Soc. 121:67-77.
- NMFS 1993. Biological opinion for the operation of the Federal Central Valley Project and the California State Water Project. 81 pages plus attachments.
- Pimm, S. L., H. L. Jones, and J. Diamond 1988. On the risk of extinction. American Naturalist 132:757-785.
- USFWS 1993. Formal consultation on Central Valley Project Operations Criteria and Plan for 1993: Effects on delta smelt. 37 pages plus figures.

Personal Communications

- Gartrell, G., CCWD, P.O. 4121, Concord, CA 94524
- Shaul, W., Jones and Stokes Ass. Inc., 2600 V Street, Suite 100, Sacramento, CA 95818-1914.
- Sweetnam, D., DFG, Bay-Delta and Special Water Projects Division, 4001 N. Wilson Way, Stockton, CA 95205-2424.

APPENDIX A

Species Account/Environmental Baseline

Longfin Smelt and Sacramento Splittail

Refer to the 1993 CVP-OCAP biological opinion for information concerning longfin smelt and Sacramento splittail.

Effects of the Proposed Action

Longfin Smelt and Sacramento Splittail

Longfin smelt spawn earlier than delta smelt so diversions in November will effect upmigrating adult longfin.

Cumulative Effects

Longfin Smelt and Sacramento Splittail

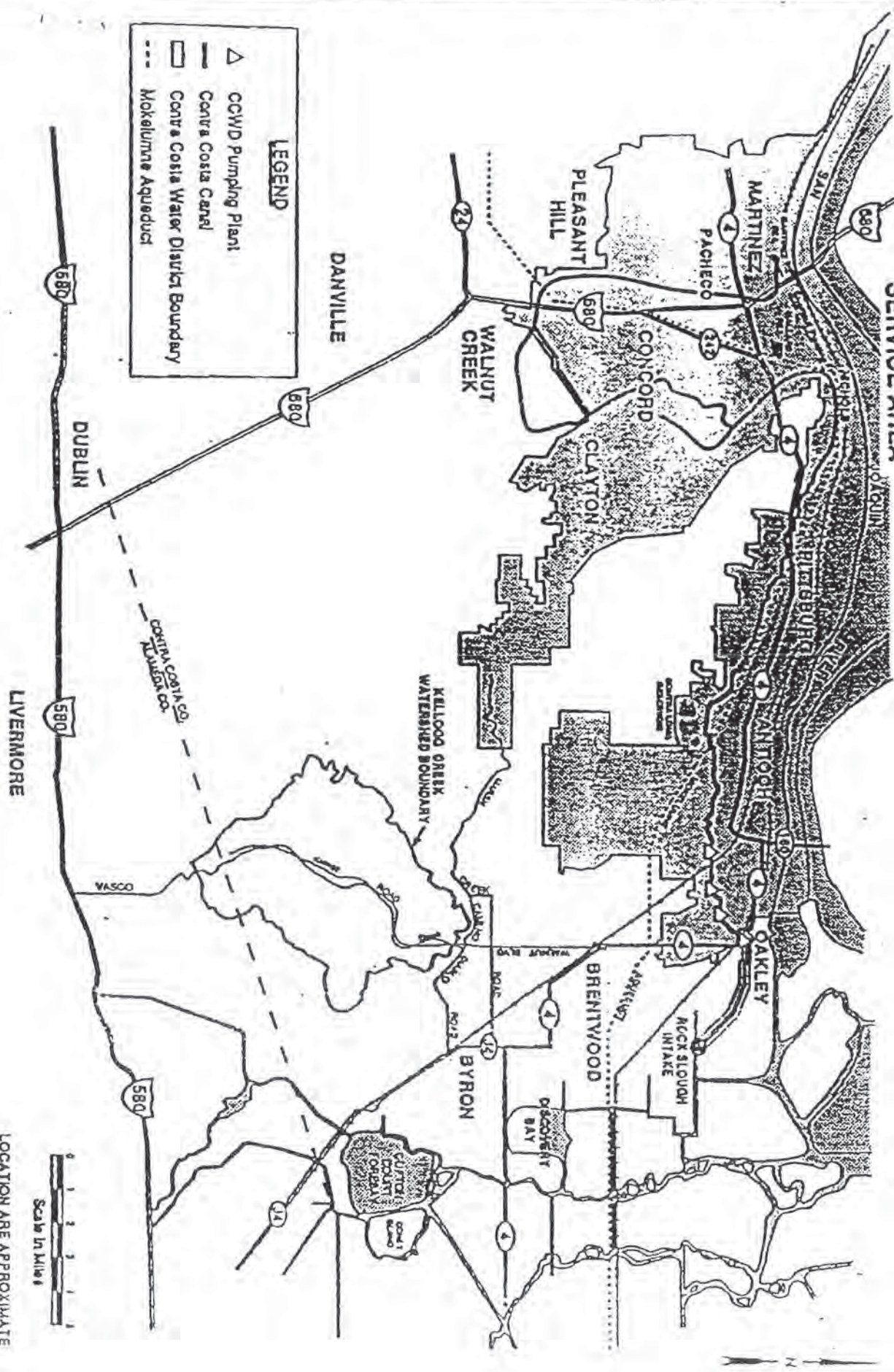
The cumulative effects described above are applicable to longfin smelt and Sacramento splittail.

Incidental Take

Longfin smelt and Sacramento Splittail

The above reasonable and prudent measures would be applicable to these two species. However, diversions should be timed to avoid taking adult longfin smelt in November.

Figure 1.
CONTRA COSTA WATER DISTRICT
SERVICE AREA



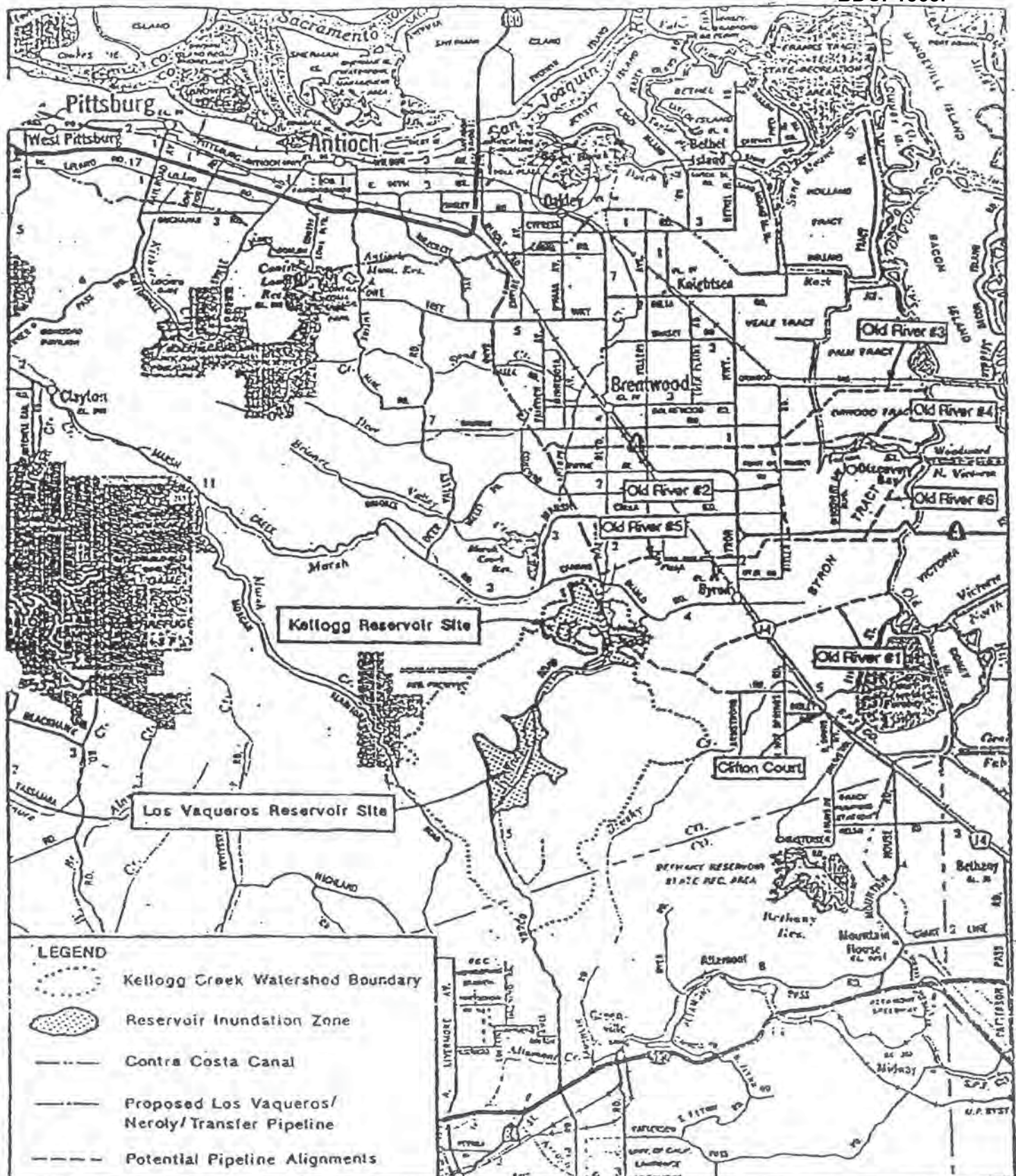
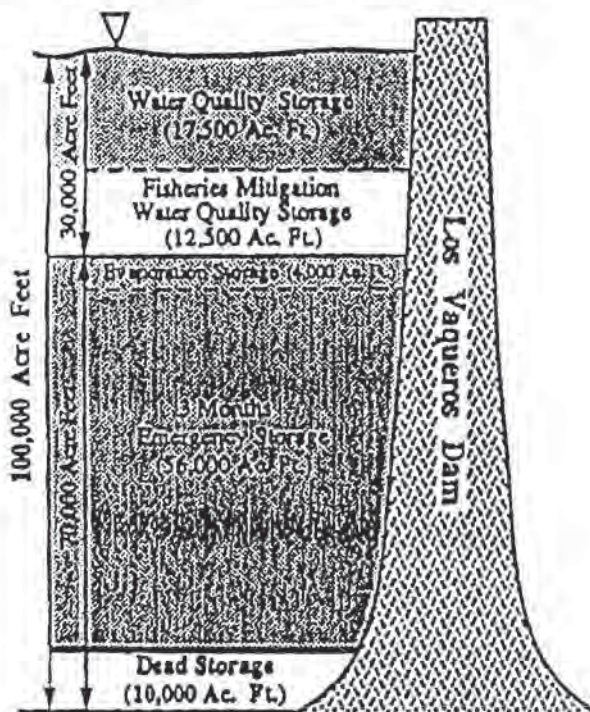


Figure 2.
Los Vaqueros
Project Alternatives

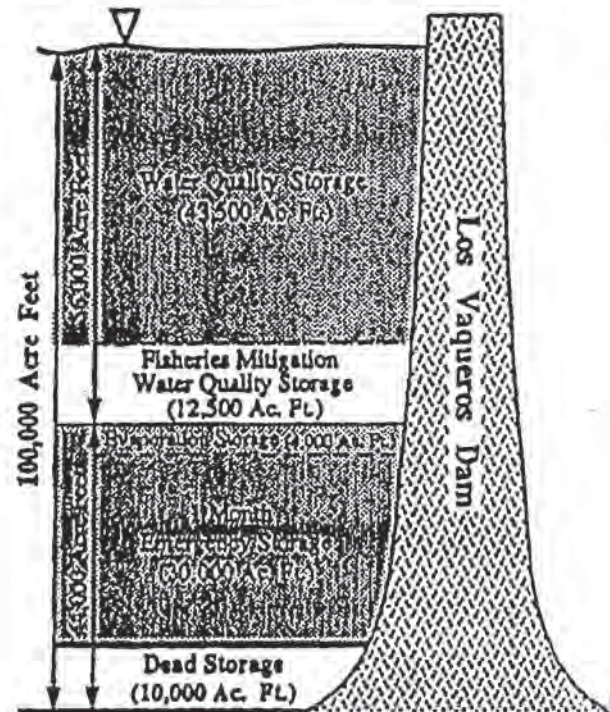


LOS VAQUEROS RESERVOIR PROJECT OPER (Mitigated For Fisheries Impacts)

YEAR TYPE: Wet, Above Normal, Below Normal



YEAR TYPE: Dry, Critical



- RULES:**
- 1) Between April 1st and April 30th of each year, CCWD will not divert any water from either Rock Slough. Instead, CCWD will release reservoir water from the Fisheries Mitigation Storage for direct use.
 - 2) After the reservoir has been filled initially, CCWD will not divert storage water from the Delta for filling between March 15th and May 31st, annually.

EXCEPTION: 1) The amount of emergency storage, which varies depending on Year Type, must always be maintained.

- NOTES:**
- 1) Year Type is defined annually by the February or possibly March edition of California Department of Water Resources' Four Basin Index defined by Water Right Decision 1485.
 - 2) It is assumed that annual evaporation is approximately 4,000 Ac. Ft. Therefore, 4,000 Ac. Ft. is added to the storage levels. Dead storage is assumed to be approximately 10,000 acre feet.
 - 3) California Department of Fish and Game, U.S. Fish and Wildlife Service, and National Marine Fisheries Service have approved the proposed operating rules.
 - 4) See proposed Operations Rules on back for specific details.

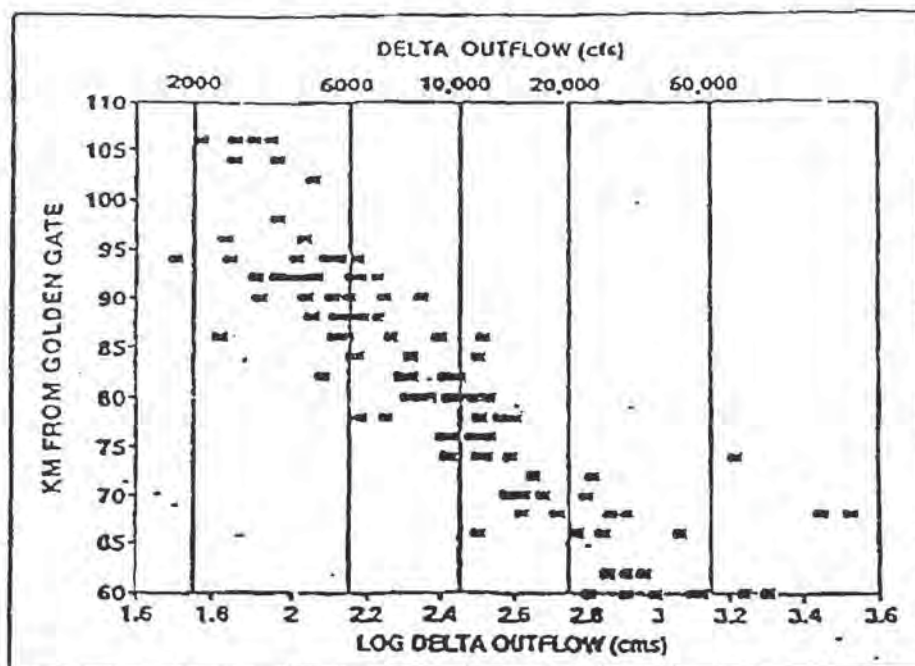


Figure 4..

**ENTRAPMENT ZONE POSITION BY THE
OPERATIONAL DEFINITION VS. LOG DELTA OUTFLOW**
(cubic meters per second)

Monthly means. Outflow values in cubic feet per second are given at the top for reference.

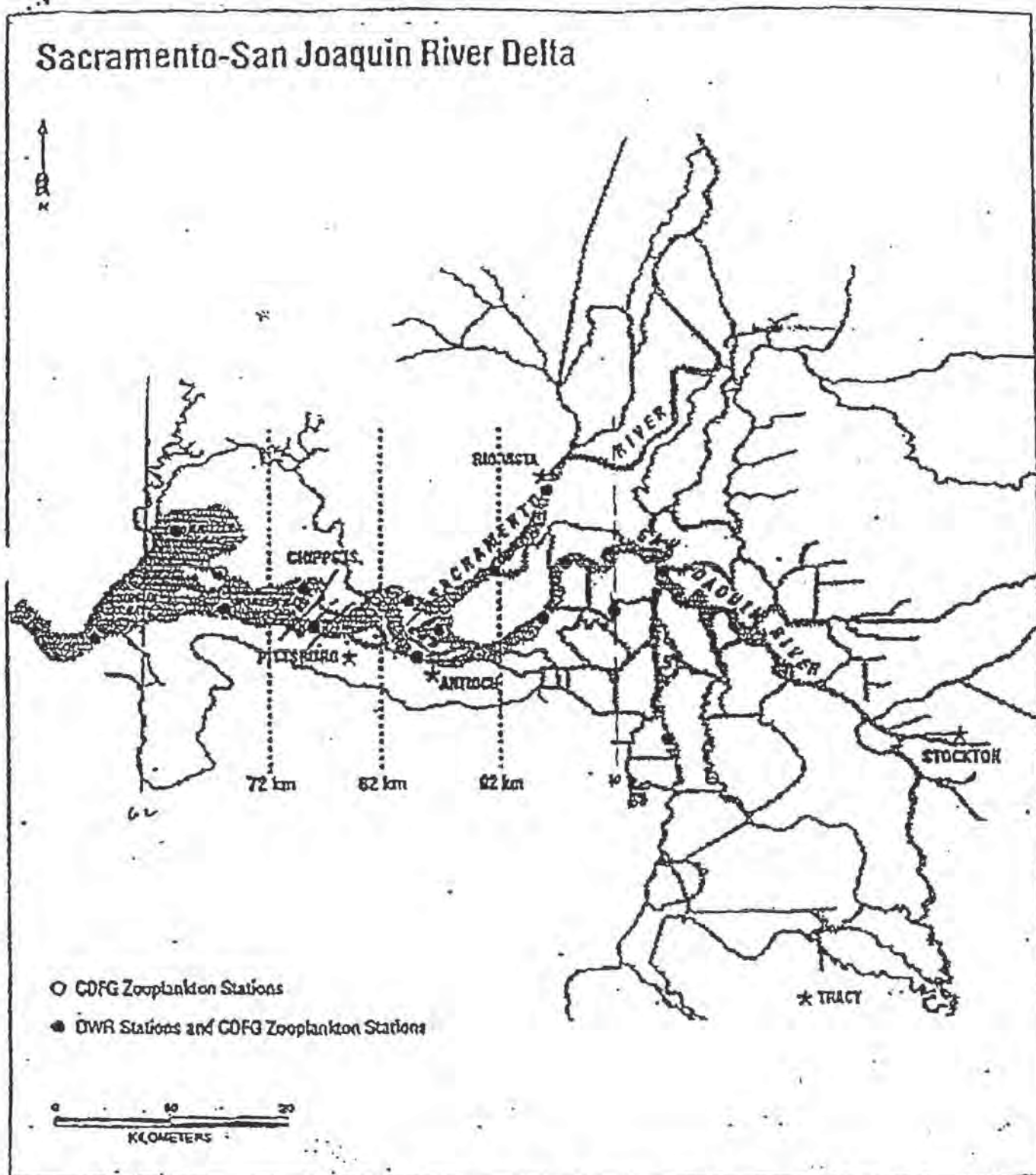
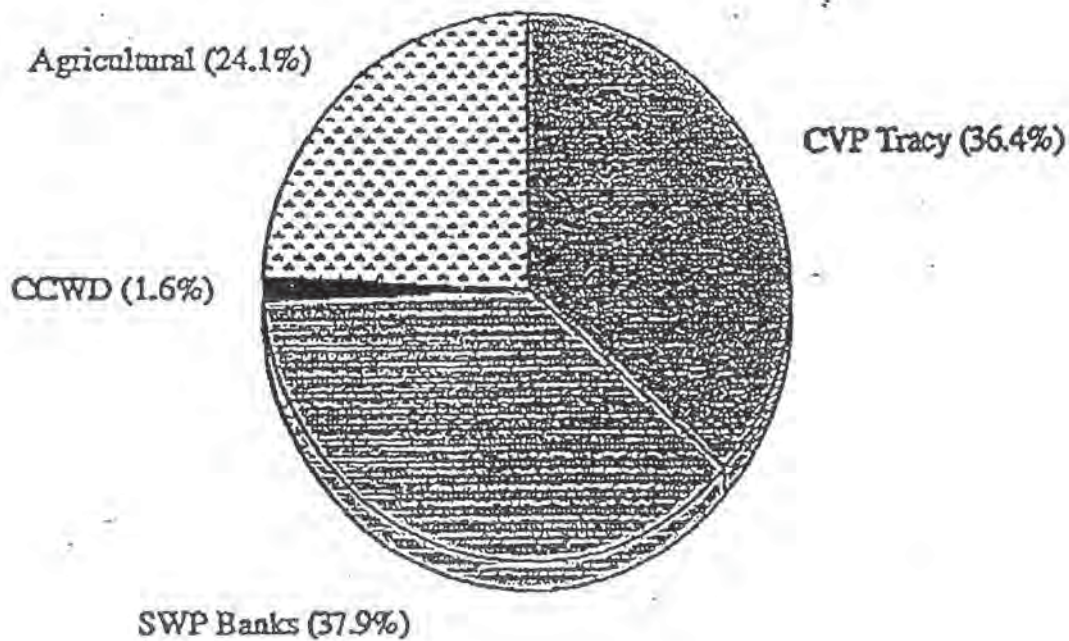


Figure 5
LOCATION MAP FOR DWR AND CDFG SAMPLING STATIONS

Vertical Lines Indicate distances from Golden Gate Bridge used to define four categories of entrapment zone position.

Figure 6.

Proportional Impacts to Delta Smelt due to Diversions from the Delta
Existing Conditions with Los Vaqueros



Total CCWD Diversions from the Delta With LVP **D1485+CVP-OCAP NMFS & FWS Opinions (G90)**

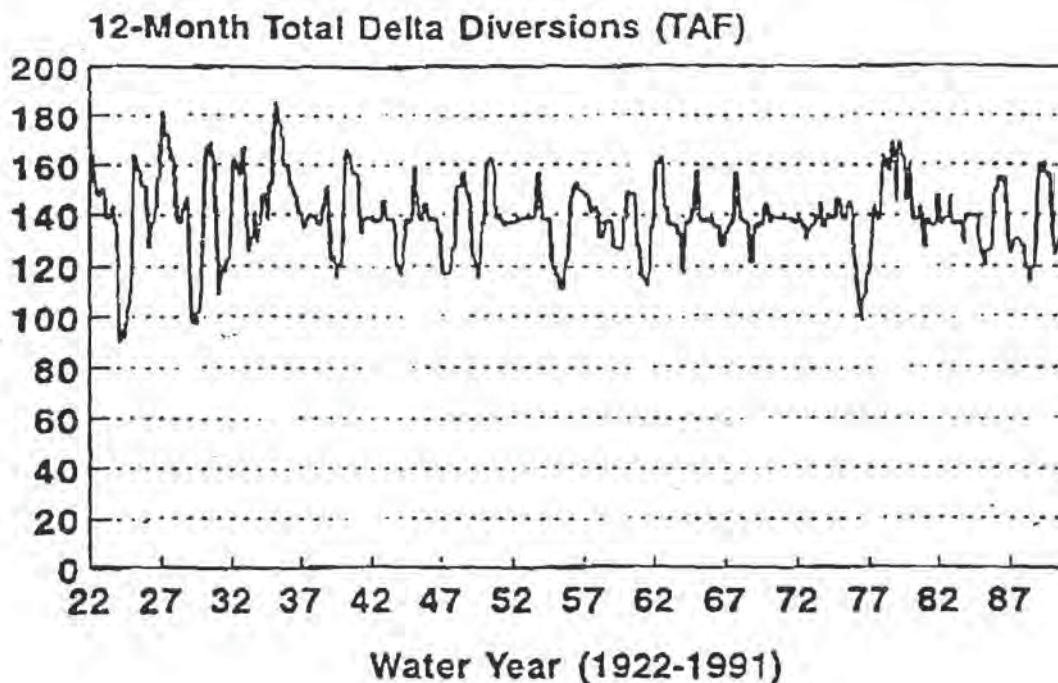


Figure 7

CCWD 12 Aug 93

CCWD Deliveries and Diversions With LVP **D1485 + CVP-OCAP NMFS & FWS Opinions (G90)**

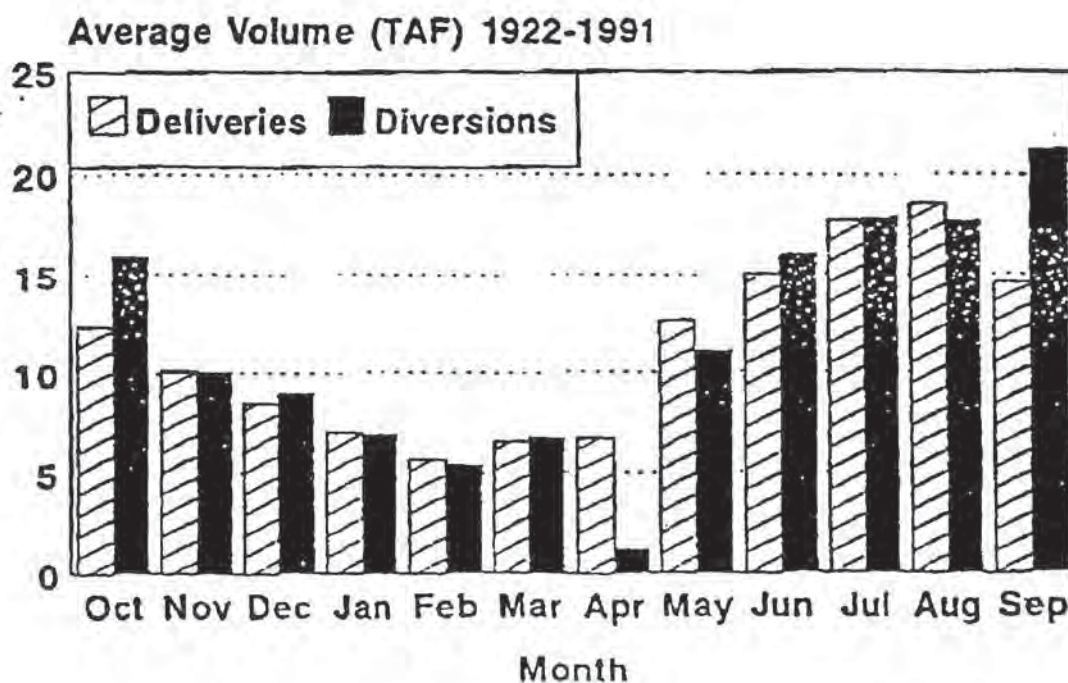
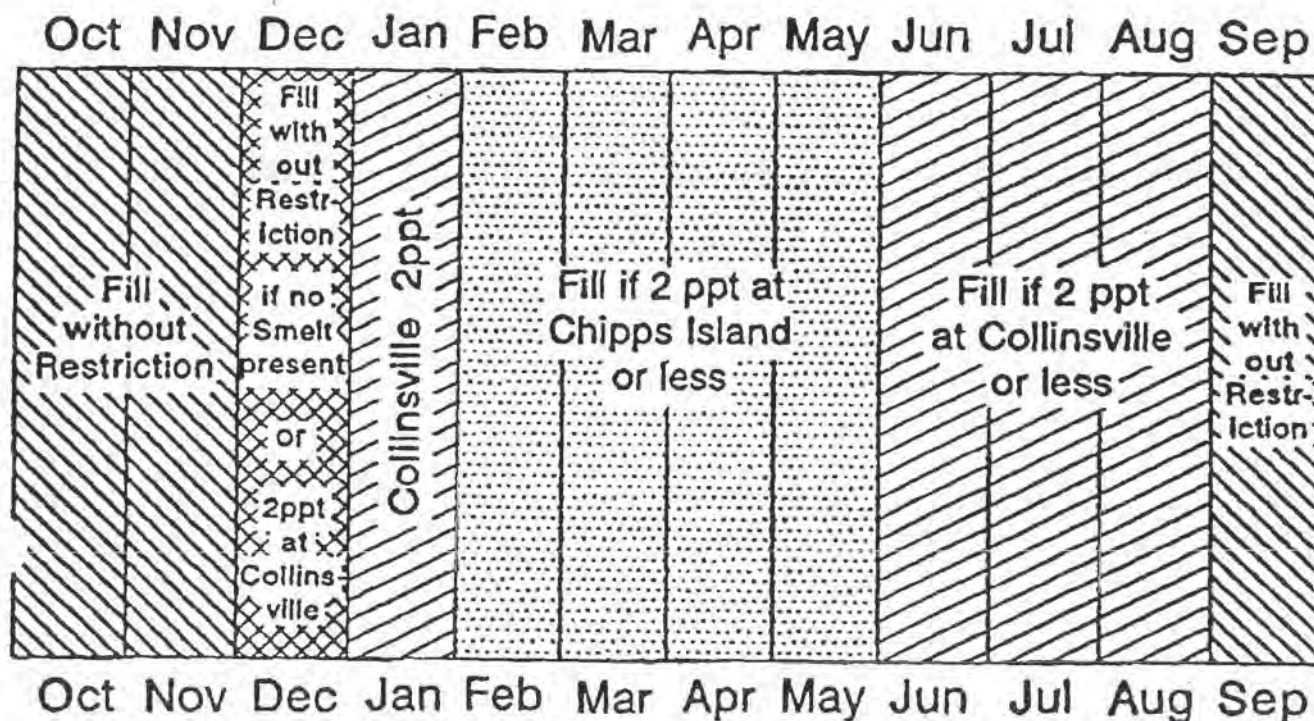


Figure 8

CCWD 12 Aug 93

Figure 9.

Los Vaqueros Filling Criteria



Note: Los Vaqueros filling is also dependent on water quality at the Old River intake

PAGE LEFT BLANK INTENTIONALLY



IN REPLY REFER TO:
1-1-99-F-93

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Sacramento Fish and Wildlife Office
2800 Cottage Way, W-2605
Sacramento, California 95825-1846



April 27, 2000

Memorandum

To: Regional Environmental Manager, Mid-Pacific Regional Office, Bureau of Reclamation, Sacramento, California

From: Assistant Field Supervisor, Sacramento, Fish and Wildlife Office, Fish and Wildlife Service, Sacramento, California

Subject: Formal Consultation Pursuant to Section 7 of the Endangered Species Act of 1973, as Amended, on Contra Costa Water District's Construction of a Multipurpose Pipeline and Future Water Supply Implementation Program, Contra Costa County, California

This attached biological opinion is in response to the Bureau of Reclamation's (Reclamation) April 28, 1999, request for formal consultation with the U.S. Fish and Wildlife Service (Service) on Contra Costa Water District's (CCWD) construction of a multipurpose pipeline and future water supply implementation program. CCWD receives its water from the Central Valley Project. Your request was received in our office on April 29, 1999. The attached document represents the Service's biological opinion on the effects to the species listed in Tables 1 and 2 of the biological opinion from the proposed action, in accordance with section 7 of the Endangered Species Act of 1973, as amended (Act). The proposed action includes the construction, maintenance and operation of a multipurpose pipeline and continued delivery of water based on current operating parameters. It also includes an analysis of effects of the secondary urban growth and development resulting from 219,400 acre/feet/year from a combination of Central Valley Project(CVP) water delivery, additional surface water rights, transferred surface water, groundwater sources and water conservation.

Full implementation of CCWD's proposed Conservation Measures described in the biological opinion is key to the conclusion that survival and recovery of the listed species in the action area would not be reduced appreciably by continued delivery of CVP water to CCWD, or by the direct and indirect effects attributable to these deliveries.

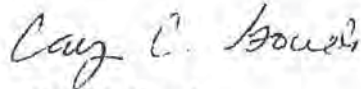
Effective coordination between the Service and Reclamation is necessary to ensure full implementation of CCWD's Conservation Measures in the biological opinion. It is important that the schedule for completion of the Habitat Conservation Plan be met. My staff and I look

Regional Environmental Manager

2

forward to working with you and your staff, as well as signatories to the Memorandum of Understanding (Attachment 4), to meet this obligation.

Please contact Ken Sanchez of this office at (916) 414-6625, if you have any questions.



Cay C. Goude
Acting Field Supervisor

Attachments

cc: PARD (ES), Portland, OR
CCWD, Concord, CA (Attn: W. Bishop)

Regional Environmental Manager

1

Executive Summary

This biological opinion addresses Contra Costa Water District's construction of the Multipurpose Pipeline, Future Water Supply Implementation program and related projects. This biological opinion sets forth the process for addressing the indirect effects on terrestrial species related to the renewal of Contra Costa Water District's Central Valley Project contract as provided under the consultation on the Implementation of the Central Valley Project Improvement Act and Operation of the Central Valley Project (1-1-98-F-0124). The proposed action includes meeting projected demands of 219,400 acre-feet per year for Contra Costa Water District's customers through 2040 via implementation of Central Valley Project water deliveries, additional surface water rights, transferred surface water, groundwater sources, and water conservation. The Future Water Supply Implementation program will meet projected water demands primarily through: (1) the renegotiation and renewal of Contra Costa Water District's Central Valley Project Amendatory Contract; (2) implementation of a conservation program for the increased service area; and (3) the purchase of water transfers to accommodate near-term drought needs and future growth. To increase reliability and capacity of Contra Costa Water District's conveyance system, Contra Costa Water District will construct the Multi-purpose pipeline. The pipeline will be partially located within the Contra Costa Canal right-of-way, which is owned by the United States.

The U.S. Bureau of Reclamation has a contract with Contra Costa Water District for the continued delivery of Central Valley Project water for a maximum delivery of 195,000 acre-feet per year, in a normal water year. An additional 26,780 acre-feet of water per year is available to Contra Costa Water District from Mallard Slough under its own water rights (however, its availability is limited by water quality and none is available in many dry years). Under the proposed action, a maximum of 205,600 acre feet (TAF) would be diverted for direct use from the Delta. The water will be used throughout Contra Costa Water District's contract service area for irrigation, municipal, and industrial purposes.

This biological opinion reviews the effects of construction of the Multi-purpose Pipeline on listed and proposed species, and the direct and cumulative effects of future water diversions on listed fish species in the Delta. It also reviews the resulting indirect effects of supplying water for urban development in the Future Water Supply Implementation project area on listed wildlife and plant species. The Service has concluded that the following five species are not likely to be jeopardized by the effects of construction of the Multi-purpose Pipeline: longhorn fairy shrimp, vernal pool tadpole shrimp, vernal pool fairy shrimp, California red-legged frog, and Contra Costa goldfields, and that the proposed water diversions are not likely to jeopardize the continued existence of delta smelt and splittail, or result in the destruction or adverse modification of critical habitat for delta smelt. The Service further concluded that the following plant and wildlife species are not likely to be jeopardized by the indirect effects of urban development associated with the Future Water Supply Implementation program: longhorn fairy shrimp, vernal pool tadpole shrimp, vernal pool fairy shrimp, California red-legged frog, giant garter snake, Alameda whipsnake, California clapper rail, California least tern, salt marsh harvest mouse, San Joaquin kit fox, Contra Costa

Regional Environmental Manager

2

goldfields, and soft bird's-beak. Scientific names of these species are listed in Tables 1, 2, and 3 in the biological opinion.

These conclusions are based on the following assumptions: 1) Contra Costa Water District and Bureau of Reclamation remain in compliance with the terms and conditions of the Biological Opinions for the Los Vaqueros Project; 2) Contra Costa Water District operates the Los Vaqueros Project according to the agreed upon Los Vaqueros Operating Rules; and 3) Contra Costa Water District's Conservation Measures will be fully implemented. Contra Costa Water District agrees to implement their Conservation Measures for the protection of listed species and their habitats in the action area. Contra Costa Water District's Conservation Measures include:

Habitat Conservation Planning. Contra Costa Water District will participate in a Habitat Conservation Plan for east Contra Costa County. The purpose of the Habitat Conservation Plan is to offset the effects of urban development on listed and proposed plant and wildlife species in the east Contra Costa County. Contra Costa Water District will contribute up to \$300,000 to fund development of a Habitat Conservation Plan for east Contra Costa County and agrees to limit its water delivery to 148,000 acre-feet per year in the interim until the Habitat Conservation Plan is completed.

Incremental Water Purchases. Contra Costa Water District provides the necessary water supplies to accommodate urban development and will continue to do so responsibly by incrementally purchasing water so that growth is not encouraged beyond that which is already planned and permitted by local land use agencies with land use authority. Contra Costa Water District will establish a monitoring process to track the impact of new development on water demand projections and available projected water supplies.

Contra Costa Water District Code of Regulations Enforcement. Under Contra Costa Water District's Code of Regulations section 5.04.120, proponents for an annexation or applicants for water service to newly annexed lands are required to provide all necessary environmental documentation and approvals by the appropriate regulatory agencies, including the Service, before Central Valley Project water can be provided. Contra Costa Water District will continue to enforce section 5.04.120, and will keep the Service informed of enforcement actions related to endangered species.

Multi-purpose Pipeline Preconstruction Surveys. Contra Costa Water District will conduct preconstruction surveys for the following listed species known to occur or having potential to occur in the Multipurpose Pipeline project area: California red-legged frog; longhorn fairy shrimp; vernal pool fairy shrimp; vernal pool tadpole shrimp; and Contra Costa goldfields. If surveys indicate any of these species are present, Contra Costa Water District will implement their Conservation Measures to avoid or minimize impacts to listed species.

The biological opinion for the proposed action authorizes limited incidental take of longhorn fairy shrimp, vernal pool tadpole shrimp, vernal pool fairy shrimp, California red-legged frog, and

Regional Environmental Manager

3

Contra Costa goldfields, delta smelt and Sacramento splittail that may occur as a direct result of construction of the Multipurpose Pipeline, routine operations and maintenance of the Multipurpose Pipeline, and delivery of 148,000 acre-feet per year water with the Los Vaqueros Project. This biological opinion **does not** exempt incidental take that results from the use or application of Contra Costa Water District water by private parties from prohibitions under section 9 of the Act.

INTRODUCTION

This biological opinion represents the U.S. Fish and Wildlife Service's (Service) biological opinion on the effects to the species listed in Tables 1, 2, and 3 from the Contra Costa Water District's (CCWD) Multi-Purpose Pipeline Project (MPP), Future Water Supply Implementation (FWSI) program and related projects, in accordance with section 7 of the Endangered Species Act of 1973, as amended (Act). It also sets forth the process for addressing the indirect effects on terrestrial species related to the renewal of CCWD's Central Valley Project (CVP) contract as provided under the consultation on the Implementation of the CVP Improvement Act and Operation of the CVP (1-1-98-F-0124). CCWD will construct the MPP to increase reliability and capacity of their conveyance system. The MPP will be located partially within the Contra Costa Canal right-of-way which is owned by the United States. The proposed action includes meeting projected demands of 219,400 acre-feet (AF) per year for CCWD's customers through 2040 by a combination of Central Valley Project (CVP) water deliveries, additional surface water rights, transferred surface water, groundwater sources, and water conservation. The FWSI program will meet projected water demands primarily through: (1) renegotiation and renewal of CCWD's CVP Amendatory Contract; (2) implementation of an increased service area-wide conservation program; and (3) the purchase of water transfers to accommodate near-term drought needs and future urban development. This biological opinion addresses the effects of construction of the MPP on listed and proposed species, the direct and cumulative effects of future water diversions on listed fish species in the Delta, and the process by which effects of urban development on listed wildlife and plant species in the FWSI project area resulting from increased water availability will be addressed.

The U.S. Bureau of Reclamation (Reclamation) has a contract with CCWD for the continued delivery of CVP water for a maximum delivery of 195 TAF in a normal water year. An additional 26,780 AF is available to CCWD from Mallard Slough under its own water rights. The water will be used throughout CCWD's contract service area for irrigation, municipal, and industrial purposes. Under the proposed action, a maximum of 205,600 AF would be diverted from the Delta for direct use. CCWD agrees to implement their proposed Conservation Measures for the protection of listed species and their habitats in the action area.

The Service has concluded that the following federally listed plant and wildlife species are not likely to be jeopardized by the secondary effects of urban growth associated with the FWSI program: longhorn fairy shrimp, vernal pool tadpole shrimp (tadpole shrimp), vernal pool fairy shrimp (fairy shrimp), California red-legged frog (red-legged frog), giant garter snake, Alameda whipsnake (whipsnake), California clapper rail (clapper rail), California least tern (least tern), salt marsh harvest mouse (harvest mouse), San Joaquin kit fox (kit fox), Contra Costa goldfields (goldfields), and soft bird's-beak. Federal status and scientific names of these species are listed in Table 1. This conclusion is based on the assumption that CCWD's Conservation Measures described in the biological opinion will be fully implemented. Specifically, CCWD has agreed to participate in the development of a Habitat Conservation Plan (HCP) for east Contra Costa County (County). The purpose of the HCP is to offset the effects of urban growth on listed and

proposed plant and wildlife species in east County. Additionally, CCWD has agreed to contribute up to \$300,000 to develop an HCP. In the interim, CCWD will limit its CVP water delivery to 148 TAF.

It is the Service's biological opinion that the proposed water diversions are not likely to jeopardize the continued existence of delta smelt and Sacramento splittail(splittail), or result in the destruction or adverse modification of critical habitat for delta smelt. Federal status and scientific names of these species are provided in Table 2. This conclusion is based on the following assumptions: 1) CCWD and Reclamation continue to comply with all the terms and conditions of the Los Vaqueros Project (LVP) biological opinions; 2) CCWD operates the LVP) according to the agreed upon LV Operating Rules which result in a benefit to Delta fisheries; and 3) CCWD's Conservation Measures described herein will be fully implemented.

Further, the Service has concluded that the following five species are not likely to be jeopardized by the construction of the MPP: red-legged frog; longhorn fairy shrimp; tadpole shrimp; fairy shrimp; and goldfields. This conclusion is based on the assumption that CCWD's Conservation Measures will be fully implemented, and that CCWD will minimize impacts for all direct impacts of construction of the MPP. Scientific names, federal status and designation of critical habitat for these species are listed in Table 3.

Table 1. Species indirectly affected by water deliveries and considered in this biological opinion, including common name, scientific name, federal status and whether the species has critical habitat.

Common Name	Scientific Name	Federal Status	Critical Habitat
Longhorn fairy shrimp	<i>Branchinecta longiantenna</i>	Endangered	No
Vernal pool tadpole shrimp	<i>Lepidurus packardii</i>	Endangered	No
Vernal pool fairy shrimp	<i>Branchinecta lynchi</i>	Threatened	No
California red-legged frog	<i>Rana aurora draytonii</i>	Threatened	No
Giant garter snake	<i>Thamnophis gigas</i>	Threatened	No
Alameda whipsnake	<i>Masticophis lateralis euryxanthus</i>	Threatened	No
California clapper rail	<i>Rallus longirostris obsoletus</i>	Endangered	No
California least tern	<i>Sterna antillarum browni</i>	Endangered	No
Salt marsh harvest mouse	<i>Reithrodontomys raviventris</i>	Endangered	No
San Joaquin kit fox	<i>Vulpes macrotis mutica</i>	Endangered	No
Contra Costa goldfields	<i>Lasthenia conjugens</i>	Endangered	No
Soft bird's-beak	<i>Cordylantus mollis ssp. mollis</i>	Endangered	No

Regional Environmental Manager

6

Table 2. Fish species directly and cumulatively affected by increased water diversions and considered in this biological opinion, including common name, scientific name, federal status and whether the species has critical habitat.

Common Name	Scientific Name	Federal Status	Critical Habitat
Delta smelt	<i>Hypomesus transpacificus</i>	Threatened	Yes
Splittail	<i>Pogonichthys macrolepidotus</i>	Threatened	No

Table 3. Species directly affected by the construction of the MPP and considered in this biological opinion, including common name, scientific name, federal status and whether the species has critical habitat.

Common Name	Scientific Name	Federal Status	Critical Habitat
Longhorn fairy shrimp	<i>Branchinecta longiantenna</i>	Endangered	No
Vernal pool tadpole shrimp	<i>Lepidurus packardii</i>	Endangered	No
Vernal pool fairy shrimp	<i>Branchinecta lynchi</i>	Threatened	No
California red-legged frog	<i>Rana aurora draytonii</i>	Threatened	No
Contra Costa goldfields	<i>Lasthenia conjugens</i>	Endangered	No

This biological opinion is provided in accordance with section 7 of the Act. CCWD was designated as Reclamation's non-federal representative on May 22, 1998. Reclamation's April 29, 1999, request for formal consultation was received on April 29, 1999.

Terms and conditions in this biological opinion address Reclamation's role in the implementation of CCWD's Conservation Measures and where additional consultation will be needed (e.g., water transfers, water conservation measures, and future operations agreement). When CCWD's Conservation Measures are implemented as part of the contract renewal process, water deliveries to CCWD can continue to be sustained, and the impacts to listed species can be reduced and listed species habitat protected from future disturbances.

The biological opinion for the proposed action authorizes limited incidental take of longhorn fairy shrimp, tadpole shrimp, fairy shrimp, red-legged frog, and goldfields, delta smelt and splittail that may occur as a direct result of construction of the MPP, routine operations and maintenance of the MPP and physical delivery of water. This biological opinion **does not** exempt incidental take that results from the use or application of CCWD water by private parties from prohibitions under section 9 of the Act.

CONSULTATION HISTORY

This biological opinion is based on information provided in:

- (1) CCWD's *Biological Assessment* (BA) prepared for Reclamation;

Regional Environmental Manager

7

(2) Project maps and supplemental information provided in numerous meetings, telephone conversations, and correspondence between members of my staff and representatives of CCWD. This includes, but is not limited to, the following:

1993, 1995, 1996: The LVP Biological Assessments (BA) and the LVP Environmental Impact Report/Environmental Impact Statement (EIR/EIS) (final October, 1993). The latter is included by reference in the MPP EIR/EIS. The following biological opinions were issued to Reclamation for the effects of the CCWD's LVP on the San Joaquin kit fox and bald eagle (1-1-92-F-48) on September 3, 1993; delta smelt (1-1-93-F-35) on September 9, 1993 (with clarification on September 24, 1993); fairy shrimp species (1-1-95-F-117) on August 7, 1995; and red-legged frog (1-1-96-F-151) on June 21, 1996, including CCWD'S BA for the LVP (prepared for Reclamation, August 1992).

October 14, 1997: CCWD, through its consultant Environmental Science Associates, requested a species list for the MPP project area. The Service sent the species list to the consultant on November 14, 1997.

January 7, 1998: CCWD and the Service met informally to discuss compliance with the Act for CCWD's MPP.

January 16, 1998: A CCWD letter report summarizing current Federal and State Act compliance activities related to Delta fisheries, reviewing future compliance issues related to Delta fisheries and requesting a meeting to discuss approaches to future compliance and the need to re-consult on delta smelt.

January 27, 1998: CCWD, the Service, National Marine Fisheries Service (NMFS) and California Department of Fish and Game (Department) met to discuss compliance with the Act for Delta fisheries for CCWD's FWSI program.

March 11, April 8, & April 21, 1998: CCWD and the Service met to discuss a programmatic approach to consultation that would comprehensively address direct effects from Delta diversions and construction of the MPP, and indirect effects related to the secondary impacts of growth within the service area associated with the availability of water supply.

May 20, 1998: Reclamation designated CCWD as the non-federal representative for the MPP.

June 17, 1998: CCWD requested that the Service confirm the programmatic approach as developed and agreed to in the above referenced meetings. The Service confirmed in writing on July 1, 1998.

Regional Environmental Manager

8

September 3, 1998: CCWD sent the Service copies of the Draft EIR for the FWSI project and the Draft EIR/EIS for the MPP, which incorporates by reference the Final EIR/EIS for LVP.

January 12, 1999: The Service provided comments to Reclamation and CCWD on the Draft EIR/EIS for the MPP. -

January 29, 1999: The Service, Reclamation and CCWD met to discuss the programmatic consultation. The Service requested: 1) a matrix summarizing compliance with terms and conditions of the LV biological opinions, 2) resolution of a discrepancy related to amount of kit fox habitat, and 3) a copy of the CEQA Findings made by the County on their General Plan.

February 1999: The Service submitted a draft Fish and Wildlife Coordination Act report to Reclamation for the MPP. The Service recieved the final FWSI EIR.

March 2, 1999: The Service met with CCWD to discuss the programmatic consultation. CCWD provided the requested matrix and clarification on the kit fox issue. The Service requested copies of certain supporting documentation referenced in the matrix.

April 28, 1999: Reclamation requested formal consultation on the MPP.

May 4, 1999: Meeting between the Service and CCWD to review the biological assessment for CCWD's future water deliveries and related projects. The Service requested additional data related to impacts on Delta fisheries.

May 7, 1999: The Service received the data related to impacts on Delta fisheries

- (4) A May 1999, draft BA addressing future water deliveries and related project prepared by CCWD;
- (5) Published information on the status and ecology of the species listed above; and
- (6) Unpublished information in Service files.

As mentioned above the Service previously issued numerous biological opinions to Reclamation for CCWD projects, as required under the Act. A biological opinion from NMFS was issued for the effects of the LVP on winter-run chinook salmon on March 13, 1993. A summary of the aforementioned biological opinions is included as Attachment 1. A summary and status of the requirements of the LVP biological opinions is included as Attachment 2. In addition, impacts to following listed aquatic species, delta smelt, splittail, winter run salmon; and steelhead, are addressed under existing CVP OCAP biological opinions (Attachment 3).

Regional Environmental Manager

9

The Service and NMFS issued biological opinions to CCWD and Reclamation for a number of species as they relate to the LVP. The biological opinion on terrestrial species was limited in scope to direct impacts within the LV watershed. The winter-run chinook salmon opinion included all direct and indirect impacts for the anticipated level of diversions through 2025 (NMFS, 1993) (including both diversions to fill the reservoir and to meet service area demand). The delta smelt biological opinion was limited in scope to 148 TAF of CVP water delivered to the service area of CCWD. The LVP BA for delta smelt analyzed all direct and indirect impacts for diversions at buildout, including both diversions to storage and to meet service area demand for a delivery of up to 148 TAF.

The LVP Final Stage 2 EIR/EIS (CCWD, 1993) found buildout demands of approximately 208 TAF by 2025. A total of 191 TAF out of the 208, is to be met by Delta diversions, with 3 TAF met by groundwater and the remainder to be met by conservation measures and water reclamation. The service area considered was the LV Service Area (Service Area A).

The analysis for the LVP biological opinion examined the effects on delta smelt and splittail from CCWD deliveries to the service area at a maximum of 148 TAF, and thus was modeled to the limit of 148 TAF. The FWSI program calculated buildout demands by 2040 to be 219 TAF, again, a certain amount would be met by implementing water conservation measures and reclamation. The FWSI program anticipates about 205 TAF to be met through Delta diversions, of which approximately 191 TAF is within the LVP Service Area A, the remainder being in the Hotchkiss-Cypress area, Bethel Island and small miscellaneous areas adjacent to Antioch and Oakley. Consequently, the FWSI considers about 15 TAF beyond the LVP EIR/EIS. The completed analysis for the FWSI includes potential demands from future service areas outside the LV Service Area.

The LVP opinion provided incidental take for delta smelt and splittail resulting from delivery of 148 TAF. The FWSI BA provides analysis on 219 TAF. The 219 TAF is requested because it takes into account the growth that will occur within the service area. However, of this 219 TAF, 205 TAF will be obtained through in-Delta diversions. CCWD anticipates that this additional water will be needed by the year 2040. (The remaining 14 TAF will be obtained through water conservation strategies and ground water (Table 4)). CCWD conducted a modeling exercise on 205 TAF for the NEPA compliance action. Due to the timeline and the unpredictability of future water supplies, CCWD decided to base this biological opinion on obtaining only the 188 TAF. Therefore, the effects that are determined for the project are minimized when the 188 TAF are taken into account.

Due to the cumulative effects of the additional 40 TAF (from the 148 TAF from the LVP to the 188 TAF for the FWSI) combined with other CVP and state-wide actions, actual impacts may differ from the analysis. The analysis presented has been conservative in several respects, and possibly overstates impacts, because it includes: 1. Conservation levels at the low range of the

BMP's, an assumption that maximizes the assumed water diversions and their impacts¹; 2. CVP operations rules that are assumed not to change with time consequently cumulative impacts in the model are likely to be higher than would be actually expected.²

Modeling of the direct effects of CCWD's diversions shows minimal impacts and net fisheries benefits with LVP. Modeling also indicates potential small, possibly negligible, negative indirect effects of CCWD's increased diversions on global parameters such as Delta outflow or channel flows. However, such changes are more directly controlled by hydrology and the actions of others, such as reservoir operations, diversions by other Delta diverters and the operations of the CVP and State Water Project (SWP) export facilities, all of which are out of the control of CCWD. CCWD has, by dedicating up to 25% of its operational storage to fisheries benefits, mitigated some or all of these impacts.

Indirect global effects such as changes in outflow and channel flows are more globally related to CVP operations and are dealt with in CVP biological opinions that address operations of reservoirs and the export facilities. Reclamation is required to operate the CVP in ways that would prevent some or all of these potential impacts. Reclamation will also be completing consultation on the contract renewals required under the CVPIA and/or a re-analysis of the CVP OCAP opinion which will address with these issues.

Therefore, CCWD has incidental take authority for an annual delivery of 148 TAF currently, and CCWD will have incidental take authority for an annual delivery of no more than 188 TAF when: 1. An HCP for the service area has been signed and the Section 10 permit(s) issued; 2. The terms and conditions for the LVP opinion are implemented and are continuing to be implemented, including the construction of the fish protection facility at Rock Slough; 3. Reclamation will initiate consultation on contract renewals; and 4. reinitiate on OCAP. The section 7 consultations for contract renewal and OCAP may result in an authorized annual delivery of up to 188 TAF. If the OCAP consultation or contract renewal consultation provides for incidental take authority of a lesser amount, then Reclamation may reinitiate consultation for the increment.

¹For example, in shortage periods, when supplies are limited, the increased diversions by CCWD will be largely, if not entirely, offset with decreased diversions by other parties, thus negating flow impacts shown in the models.

²CCWD only counts water savings from "hard" conservation measures (ULFT's, faucet and shower retrofits, etc.), whereas "soft" conservation measures (habit changes, water audits, etc.) are not counted since the reliability may vary and degrade with time. Thus, conservation levels are conservative and likely to be understated.

Regional Environmental Manager

11

BIOLOGICAL OPINION

Action Area

The action area is defined in 50 CFR 402.14(g)(3) as the immediate area involved in the action and the entire area where effects to listed species extend as a direct and indirect effect of the action. The action area for this proposed action includes the direct impacts resulting from water diversions and the construction footprint of the MPP, and the indirect impacts of facilitating urban growth resulting in part from the FWSI.

Description of the Proposed Action

Project Overview

CCWD is planning several activities related to the delivery of water to its customers to the year 2020 and beyond. These actions include: 1) construction of the MPP; and 2) implementation of the FWSI program, which provides a plan for meeting the expected water supply needs for CCWD's customers through 2040, including the renewal of the water service contract with Reclamation through the CVP. Contract renewal is expected to occur in late 1999 for a renewal period of 25 years.

The MPP provides the physical means to convey and deliver existing and future water supplies, as well as substantially increase reliability of the existing conveyance system. The FWSI program provides the water supply needed to meet customer demands.

Existing annual water deliveries are approaching 148 TAF, and Delta diversions are projected to approach 205,600 AF by 2040. This proposed action includes meeting projected demands of 219 TAF through a combination of CVP water deliveries, additional surface water rights, transferred surface water, groundwater sources, and water conservation. Existing diversion facilities at Old River, Rock Slough and Mallard Slough are assumed to be relatively unchanged, except that fish screens are currently designed and will be completed for the Rock Slough and Mallard Slough diversions by the year 2001. The following table summarizes the demand levels used in the LV biological opinions and those covered here.

Table 4. Summary of the planning horizon, service area, total demand, Delta impact, and terrestrial impact for the Los Vaqueros and FWSI/MPP projects as addressed in biological opinions.

	Anticipated Level of Development/ Planning Horizon	Service Area ¹	Total Demands ²	Delta Impact Analysis ³	Terrestrial Analysis
Los Vaqueros	2025	LV Planning Area (1994) represented as "Existing Service Area"	206 TAF	188 TAF	LV Watershed
FWSI/MPP	2040	FWSI Project Area	219 TAF	205 TAF	FWSI Project Area

Notes:

¹ See Figure 1.

² Total Demands are based on a normalized demand, regardless of who serves or the source of supply (groundwater, conservation, reclamation, other water rights holders, CVP contract).

³ Diversions from the Delta to meet demands represent Total Demands minus demands met by other sources (conservation, reclamation, groundwater or other non-Delta supplies). The analysis actually covered Total diversions including the diversions to meet customer demands listed in the Table plus diversions to operate Los Vaqueros.

It was recognized during the LVP consultation that new facilities would be required to meet demands due to urban expansion. The MPP involves construction and operation of two new pipelines (Fig. 1) and pump stations (Fig. 2), together with improvements to the existing Contra Costa Canal (Canal). The purpose of the MPP is to improve system reliability, including the ability to meet demands following a major earthquake or fire emergency; increase capacity of CCWD's water conveyance system; and increase operational flexibility.

MULTI-PURPOSE PIPELINE

The Canal system is the only conveyance facility through CCWD's raw-water service area; there is no facility that provides adequate backup in the event of an emergency, such as Canal damage resulting from an earthquake. Additionally, the Canal system does not have adequate conveyance capacity to meet existing-plus-projected future water demands within CCWD's service area. The Canal is an element of the CVP, built by Reclamation in 1948 and operated by CCWD. The terms for repayment of the project works are defined in the Amendatory Contract for Water Service (Contract No. I75r-3401) between CCWD and Reclamation. To meet future demands and provide reliable service under normal conditions and emergency scenarios, CCWD proposes to implement the MPP Project, which will expand and modify the existing CCWD water conveyance system.

The MPP involves the construction and operation of two new pipelines and associated pump stations and other improvements to the existing Canal. Figure 1 shows the location of the proposed pipeline alignment for the MPP and RWP and figure 2 shows the proposed pump stations. The project would increase the reliability and capacity of CCWD's raw-water delivery system to meet existing and new customer needs. It would improve system reliability by improving water flows for firefighting after a major earthquake or fire emergency and facilitating maintenance and repair of the Canal.

The MPP facilities would supplement the capacity of the Canal in two ways. First, the proposed 20-mile MPP and associated pump station would carry treated water from the Randall-Bold Water Treatment Plant (WTP) in Oakley to CCWD's Treated Water Service Area (TWSA). The MPP would free up capacity in the Canal that is currently used to meet customer demands in the TWSA. Currently the Canal is running out of capacity, and freeing up capacity would enable CCWD to meet growing raw-water demands along the Canal. In addition, CCWD's Bollman Water Treatment Plant in Martinez, which currently serves the TWSA, is approaching its operating capacity. The MPP would deliver additional treated water to the TWSA to supplement the Bollman WTP supply. The MPP needs to be implemented before TWSA demand exceeds the capacity of the Bollman WTP. Second, the proposed Raw Water Pipeline (RWP) and Pump Station would be constructed to bypass an existing bottleneck along the Canal, located between Pumping Plant 4 and an area west of Lone Tree Way, near Sunnyridge Park. Specifically, constriction occurs where the Canal enters a tunnel in eastern Antioch, at the Lone Tree Siphon, and at the Canal crossing at Lone Tree Road. When the constricted areas reach capacity, water would be pumped out of the Canal and into the RWP. The RWP would convey raw water past the constricted areas, emptying back into the Canal four miles downstream near the Antioch turnout. To improve flow through the Canal, the MPP includes modifications to existing features in the Canal, the Canal gates, and Neroly Blending Facility.

Project Location

CCWD is proposing to construct the 20-mile MPP within the existing Canal right-of-way (ROW) (owned by Reclamation) between the Randall Bold WTP and the Cal Cities WTP. West of the Cal Cities WTP, it will be routed along the Mallard Pipeline ROW (owned by CCWD) and then adjacent to the Port Chicago Highway to the pipeline's terminus. The RWP would also be constructed within the Canal ROW generally between Pumping Plant 4 and the Antioch Pump Station. The MPP Pump Station and the Raw Water Pump Station sites are located at the Randall-Bold WTP and CCWD's Antioch Service Center (Canal operations center), respectively. The Canal gates and the Neroly Blending Facility are existing facilities within the Canal that would be modified.

A description of each of the proposed MPP Project components, including general design characteristics, project location, and proposed construction and operation scenarios follow. This discussion is supported by Figures 3a through 3c, which present the preferred pipeline alignment

on a topographic base map and show local surface-water drainages and wetland features along the alignment.

Multi-Purpose Pipeline and Pump Station. The proposed MPP extends approximately 20 miles from the Randall-Bold WTP in Oakley to CCWD's treated water system in Concord. The MPP would be designed with connection points (stubouts) to allow future interties with the treated water systems in Antioch, Pittsburg, and Bay Point. The connections would be in proximity to the water treatment plants serving these communities. Interties would allow CCWD to provide treated water to these communities, if an emergency interrupts plant or Canal operations. No pipeline alignments have been identified for these interties. If implemented, CCWD would determine whether supplemental environmental review would be necessary to consider the impacts of constructing these interties.

Multi-Purpose Pipeline Operations. The MPP would be designed to operate in different ways to serve different purposes.

Under normal operations, the MPP would convey treated water westward from the Randall-Bold WTP in Oakley to the TWSA. The capacity of the Randall-Bold WTP, jointly owned by Diablo Water District and CCWD, is 40 million gallons per day (mgd). The Diablo Water District has 15 mgd of the plant's capacity and CCWD has the remaining 25 mgd of capacity. The MPP would make use of CCWD's 25-mgd capacity by providing a means by which to transport the treated water to the TWSA.

The project includes connections between the MPP and the Canal for emergency operations. Four emergency connections will be constructed along the Canal, the locations of which are based on emergency water-demand projections for Canal customers (Fig. 2). A fifth connection to the existing Shortcut Pipeline would improve reliability and flexibility in providing emergency service. (The Shortcut Pipeline connects the Canal directly to the Martinez Reservoir, the western terminus of the Canal.) Each emergency connection would require a Canal inlet structure, a vault, and power to the site. During normal MPP operations, the emergency valves would be closed.

Multi-Purpose Pipeline Location. The MPP alignment is mainly within the existing ROW of the Canal and the Mallard Pipeline (Fig. 1). The alignment generally is on the north side of the Canal on an access road. The north side is known as the "operations side," because it is used for the majority of Canal operations and maintenance activities. The operations side width ranges from 50 to 160 feet. The operations road is typically 12 feet wide and gravel, but is paved where it serves as the multi-use Delta De Anza Trail. The south side of the Canal, known as the non-operation side, has a dirt or gravel access road along some segments. The MPP may be installed on the non-operations side between Neroly Road and Pumping Plant 4, depending on the suitability of the operations side for construction.

On the west end, the MPP would be placed within CCWD's property for the existing Mallard Pipeline. The Mallard Pipeline conveys water from Mallard Slough to Mallard Reservoir. The

Mallard Pipeline ROW is 20 feet wide and located south of the southernmost set of railroad tracks that traverse the Concord Naval Weapons Station, formerly the Sacramento Northern Rail Line. West of Main Street, the Mallard Pipeline crosses Port Chicago Highway and parallels the east side of the highway to just north of Clyde near the existing Shortcut Pipeline crossing. The exact location of Mallard Pipeline within the easement is not known. In some areas, the Mallard Pipeline may need to be removed or replaced to accommodate operation of both the MPP and the Mallard Pipeline. CCWD examined several other alignments through the Naval Weapons Station in its Draft EIR/EIS. Final determination of the alignment is dependent on negotiations with the Navy. For purposes of this biological opinion, the alignment with the most potential to impact endangered species, the Mallard alignment, will be analyzed.

The MPP alignment follows public streets in three areas. Between the Randall-Bold WTP and Neroly Road (unincorporated County east of Antioch); the alignment follows Laurel Road (Fig. 3c). The MPP alignment also follows the Port Chicago Highway in two locations: between the Canal and the Mallard Pipeline ROWs just west of the Cal Cities WTP, and from the Mallard Pipeline ROW immediately north of the City of Clyde to the western terminus of the MPP at the Bates Avenue/Port Chicago Highway intersection (Figure 3a).

Multi-Purpose Pipeline Pump Station. The proposed MPP Pump Station would pump water from the Randall-Bold WTP clearwell (a reservoir at a water treatment plant that is used to store treated water) through the MPP to the TWSA. The 25-mgd MPP Pump Station would be located at the Randall-Bold WTP, south of the existing clearwell in the space reserved for a future pump station. Platforms for the six MPP pumps were constructed when the Randall-Bold WTP was constructed. The MPP Pump Station would also have a 3,240 square foot substation (transformer and electrical metering). The combined area, including the above facilities, the diesel tanker parking, and the generator is nearly 10,000 square feet.

Raw Water Pipeline and Pump Station. The RWP would be constructed to bypass an existing bottleneck along the Canal, located between Pumping Plant 4 and an area west of Lone Tree Way. One section of this bottleneck, the tunnel, could reach capacity as early as 1999. The RWP would be constructed generally between Pumping Plant 4 and the Antioch pump station.

Raw Water Pipeline Operations. The Raw Water Pump Station would pump water out of the Canal at a location downstream of Pumping Plant 4 and into the RWP. Water would be conveyed westward, emptying into the Canal 4 miles downstream near the Antioch turnout and would operate when flows in the Canal are at 320 cubic feet per second (cfs). Periods of high canal flow reflect peak-use periods that occur during summer months. As demand approaches 2020 levels, use of the RWP would increase.

Raw Water Pipeline Location. The RWP would be installed within the existing Canal ROW (Fig 1). Within that ROW, the preferred location is within the operations road, however, the RWP placement within the Canal ROW would have to be coordinated with the MPP. The RWP would be located on the south, non-operations side for at least 1/2-mile of its 4-mile route and would

cross over to the non-operations side after the tunnel section. If the construction width is not adequate between the tunnel and Hillcrest Avenue, the RWP would require an easement through private property to reach Hillcrest Avenue. West of Hillcrest Avenue there may be sufficient width on the operations side of the ROW for both the MPP and the RWP. Some areas on the non-operations side of the ROW may be available for construction.

Raw Water Pump Station. The proposed RWP Station would pump water from the Canal into the RWP, around the tunnel, and back to the Canal at the Antioch Pump Station. The station would be located at the CCWD Antioch Service Center, downstream of Pumping Plant 4 and the Randall-Bold WTP turnout (Fig. 1). The facility requires approximately 9,600 square feet (80 by 120 feet).

Improvements to Canal Gates. Seven check structures in the Canal that allow operations staff to maintain desired levels of flow in the Canal. Each check structure has three bays. Two of the bays contain operable gates; the third bay is usually blocked off with stop logs (i.e., water must flow around the third bay). A third motorized Canal gate will be installed at six of the check structures to increase flow rates, thereby increasing Canal capacity.

Improvements to Neroly Blending Facility. The Neroly Blending Facility is a section of the Canal about 50 feet downstream of Pumping Plant 4 near the location of the LV pipeline discharge. Blending is achieved by mixing water from the Sacramento-San Joaquin Delta with water from the LV Reservoir around concrete and post boards. The outlet to the Randall-Bold WTP is about 70 feet farther downstream, and the outlet for the Raw Water Pump Station would be just downstream of the Randall-Bold WTP outlet. Proposed improvements involve widening the Canal by up to 7 feet along a maximum 250-foot section and installing mixing structures.

PIPELINE, CONSTRUCTION, MAINTENANCE AND REPAIR

Construction. In most areas, the MPP and RWP would be installed using open-cut trenching. Other construction techniques, including jacking and boring, would also be employed where open-cut trenching is not feasible (e.g., because of limited construction area or geotechnical conditions). Table 4 summarizes the approximate construction characteristics for all MPP Project facilities such as crew size, number of crews operating simultaneously, construction duration, and proposed permanent and temporary easement widths.

Open-Trench Construction. Open-trench construction involves excavating a trench at the desired depth, placing the pipeline, backfilling the trench after pipe installation, and restoring the surface to preconstruction conditions. Trench width would range from 4 to 6 feet and trench depth would average 7 feet.

The active work area would extend about 5-10 feet to one side of the trench and 20-30 feet to the other side, allowing access by trucks and loaders. The minimum construction easement would be 25 feet wide; the maximum generally would be 50 feet wide.

Table 4. Multi-purpose Pipeline Project Construction Characteristics

Construction Activity	Multi-Purpose Pipeline	Raw Water Pipeline	Multi-Purpose Pipeline Pump Station	Raw Water Pump Station	Neroly Blending Facility/Gate 1 Modifications
Pipe Diameter	36 inches	36 inches	-	-	-
Construction Right-of-Way Width	Minimum: 25 feet Maximum except CNWS: 50 feet Maximum through CNWS: 60-80 feet	Minimum: 25 feet Maximum: 50 feet	-	-	-
Permanent Right-of-Way Width	20 feet	20 feet	-	-	-
Construction Duration	Average 160 feet/day	Average 160 feet/day	12 - 18 months	12 - 18 months	2-6 months/1 month
Trench Width	5 feet	5 feet	-	-	-
Average Trench Depth	7 feet	7 feet	-	-	-
Length	19.7 miles	4 miles	-	-	-
Excavation Per Crew (Cubic Yards/Day)	210	210	-	-	-
Imported Backfill Per Crew (Cubic Yards/Day)	Up to 165	Up to 165	-	-	-
Crew Size	12	12	15-30	15-30	15
Number of Crews/Day	Maximum: 6	Maximum: 6	1	1	1

CNWS = Concord Naval Weapons Station

SOURCES: Contra Costa Water District, Camp Dresser and McKee, and Environmental Science Associates 1998.

Staging areas would occur at various locations along the construction routes for storage of pipe, construction equipment, and other materials and would be located at the Antioch Service Center, along the Canal, in parking lots, vacant lots, or segments of temporarily closed street lanes. Staging areas would be selected to minimize hauling distances and long-term disruption.

Jacking and Boring. The jacking and boring method involves use of a horizontal boring machine or auger to drill a hole and a hydraulic jack to push a casing through the hole. As the boring proceeds, a steel casing pipe is jacked into the hole; the pipeline is then installed in the casing. The casing is jacked using a large hydraulic jack in a pit located at one end of the crossing. The jacking pit is excavated (and shored) with typical dimensions of 12-15 feet wide, 30-35 feet long, and depth dependent on the crossing but not less than 8-10 feet deep. This method may be used at siphon crossings (large underground pipes that convey the water under pressure from one section of open-Canal channel to the next), railroad crossings, and the Diablo Creek crossing, depending on site-specific geotechnical conditions.

Construction Duration. The pace of work is estimated to average 160 feet per day per crew along the entire route; the overall active work zone on any given work day would be 300-600 feet long. There could be up to six crews working at any one time at different locations along the pipeline.

Pipe Cradles. The Canal crosses under State Route 4 in Bay Point near Bailey Road. The clearance between the bridge and the Canal prevents open-cut trenching, the pipeline would be placed above ground and anchored onto pipe cradles.

Maintenance and Repairs. To maintain the MPP and RWP, operation and maintenance crews would drive along the pipeline alignment daily to check for signs of leaks. If a leak occurred, a crew would be dispatched to dig up the pipe and seal the leak (expected to take 1-2 days).

FUTURE WATER SUPPLY IMPLEMENTATION

The FWSI program identifies project components through which CCWD can develop future supplies and increase reliability of service to customers through the year 2040. FWSI program objectives include maintaining flexibility in meeting future demand and maintaining responsiveness to changing conditions. The program consists of both an action plan to meet near-term demands and a long-term approach to respond to changing conditions through 2040.

Need for Future Water Supplies

CCWD has a contract for 195 TAF of CVP water in a normal water year. CCWD's supply can be reduced when regulatory restrictions exist. Reductions can result from hydrological conditions as well as environmental requirements, such as diversion restrictions or water releases for fish and wildlife uses. CCWD estimates that regulatory restrictions could occur as much as fifty percent of the time. In a drought year, estimated to occur at a frequency of 1 year in 7, Reclamation can reduce CCWD's CVP water to the lesser of 75 percent of the Amendatory Contract amount or 85 percent of historical use, but never less than 75 percent of historical use.

FWSI Project Area

The existing CCWD service area comprises approximately 127,900 acres in central and northeast County serving a population of about 400,000. The project area includes both a raw-water service area (RWSA) and TWSA. The RWSA consists of water retailers, including the Cities of Antioch, Martinez, and Pittsburg; Southern California Water Company (for Bay Point); and Diablo Water District (for Oakley). Raw-water service is also provided to close to 100 industries and major businesses, agricultural users, and landscape irrigators. The TWSA includes Clayton, Clyde, Concord, Pacheco, Port Costa, portions of Pleasant Hill, Martinez, and Walnut Creek, and unincorporated areas of the County.

In 1996, CCWD calculated demands for their existing service area and an expanded service area (i.e., the FWSI project area) (Fig. 1) through the year 2040. These additional lands total approximately 12,280 acres, and would serve an additional 19,840 people in the year 2010. Based on information from the County and city land use agencies and the Association of Bay Area Governments, CCWD estimated buildout population in the FWSI project area at approximately 600,000, an increase of 200,000 people from current population estimates.

FWSI Program Components

The study projected demands of 219,400 AF by 2040. These demands would be met primarily through: 1) deliveries from CVP, which requires the renegotiation and renewal of CCWD's CVP Amendatory Contract (under the CVPIA); 2) an increased water conservation program with a projected additional 5 percent reduction in demand beyond programs already in place; and 3) the purchase of water through transfers to accommodate near-term drought needs with the flexibility to accommodate future needs as CCWD's customer base increases. The projected use of these sources to meet future demand (2040) is quantified in Table 5.

Table 5. Projected water use of CVP, San Joaquin River, water transfer, groundwater, and water conservation sources by water year type. (in thousand acre feet)

Year Type	CVP	San Joaquin River	Transfers	Total Delta Diversions	Conservation/ groundwater	TOTAL
50% wetter years	185	20	0	205	14	219
50% drier years	166	5	34	205	14	219
Critical year	146-166 (a)	0	39-59 (b)	205	14	219

a) Depends on CVP allocation; modeling assumptions used worst case for maximum river and storage impacts

b) Depends on CVP allocation; demand management could be used to minimize transfers; modeling assumptions used worst case for fishery impacts

CVP Amendatory Contract

Renegotiation and renewal of the CVP Amendatory Contract will occur immediately on completion of the CVPIA Programmatic EIS. Water allotments under renewed CVP contracts may be based on new estimates of CVP supply that take into account the CVPIA and other new regulations. In many years, future water deliveries may be reduced by as much as 15 percent. If reductions are spread evenly among the contractors, CCWD could receive as little as 166 TAF of CVP water during some years, and possibly less during regulatory restricted or drought years, beginning between 2000 and 2010. Future CVP supplies could be further affected by drought shortages; reallocation of agricultural, municipal, and industrial entitlements to meet environmental needs; changes in water quality standards in future San Francisco Bay-San Joaquin/Sacramento Delta (Bay-Delta) proceedings; and the security of the Delta as a transfer and transport system.

Water Conservation

The FWSI water conservation program is projected to achieve at least an additional overall reduction in water demands of 5 percent (approximately 11,400 acre feet) by 2040; CVP supplies, water transfers, and local groundwater will provide the remaining 208 TAF. This 5 percent savings is a minimum estimate and additional savings could occur as a result of state and federal regulations and the normal replacement of fixtures and devices with more water-efficient models.

Water Transfers

The FWSI program recommends water transfers as a means to strengthen drought protection for existing customers and meet supply shortfalls. The transfers or purchases would include water

Regional Environmental Manager

21

purchased from East Contra Costa County Irrigation District for short-term and dry-year needs and from north of the Delta to provide additional supplies to meet future needs. CCWD estimates that by 2040 it will need an average of 34 TAF fifty percent of the time and up to 59 TAF in a critical year. Incremental transfers would be pursued as the customer base grows over time. Project-level environmental documentation, including consultation as required under section 7 of the Act, for individual transfers would occur when those transfers are negotiated.

Operations

The FWSI assumes that CCWD will operate under the terms and conditions of its permits and biological opinions for the LVP. These operations provide for shifting diversions to periods of high out flow and good water quality and away from sensitive fishery periods. LVP improves X2 and other flow and salinity parameters at buildout despite increased demands.

CCWD'S CONSERVATION MEASURESDevelopment of a Habitat Conservation Plan

To offset the direct and potential indirect (i.e., urban growth) effects of the MMP and FWSI, CCWD commits to: performing all the protection measures set forth below; signing a memorandum of understanding with east-county land use agencies to develop and implement a HCP; contributing up to \$300,000 to develop the HCP; and, continuing to limit deliveries in the service area to a maximum of 148 TAF until a section 10(a)(1)(B) permit has been issued by the Service.

The proposed HCP will generally cover east County. The planning boundaries for the HCP may include, but is not limited to, the planning areas of the cities of Antioch, Brentwood, Clayton, Oakley, Pittsburg, and the County. The size of this planning area is approximately 185,000 acres. The exact planning area and specific lands to be covered under the HCP will be identified during HCP development.

Federally listed species to be covered by the HCP are: longhorn fairy shrimp, vernal pool tadpole shrimp, vernal pool fairy shrimp, California red-legged frog, Alameda whipsnake, San Joaquin kit fox, and Contra Costa goldfields. Additional federally listed species and unlisted species may be added to the covered species list during HCP development.

Activities that will be covered under the HCP, and their impacts to upland and wetland habitat and species mitigated and minimized are: urban development, including residential, commercial and industrial development; road construction and maintenance; and, water infrastructure projects, including diversions, delivery, and conveyance infrastructure. Additional activities that

may be covered under the HCP include, but are not limited to, flood control project construction and maintenance, wind energy development, sanitary system infrastructure, and construction and operation of recreation facilities. Additional activities may be added to the covered activity list during HCP development.

The HCP development will begin in early 2000 with the crafting of necessary agreements and scoping of the project. A Memorandum of Agreement is currently being developed by CCWD (Attachment 4). The goal is to release the draft HCP to the public by summer 2001, with adoption of the final HCP and issuance of the 10(a)(1)(B) permit by the end of 2002.

Biological Conservation Measures for the Construction and Maintenance of the Multi-purpose Pipeline

CCWD will conduct pre-construction surveys for the following listed species known to occur or having potential to occur in the MPP construction area: red-legged frog; longhorn fairy shrimp; fairy shrimp; tadpole shrimp; and goldfields. If surveys indicate any of these species are present, CCWD will take the measures specified below to avoid or minimize impacts to listed species.

California Red-legged Frog

1. To avoid and minimize the potential effects on the red-legged frog and its habitat associated with trenching the pipeline through drainages that support potential habitat (drainages 2b, 4, 6, 7, 12, 13, 16b, 17a, 20a, and 21 b)(Fig. 3a-3c), the following measures will be implemented:

- a. Pipeline drainage-crossing construction corridors will not exceed a width of 25 feet through the drainage channel and associated riparian habitat area.
- b. Preconstruction surveys to determine presence of red-legged frogs will be conducted at each pipeline drainage crossing within 15 days before construction begins at each site. Surveys will be designed to locate juveniles and adults and depending on when construction is to be initiated, egg masses and tadpoles. Survey results will be provided to the Service before construction is initiated. If no red-legged frogs are detected during these surveys, construction-related activities will proceed.

If egg masses, tadpoles, juveniles, or adult red-legged frogs are found within the construction corridor, they will be captured, removed and relocated to suitable adjacent habitat by a biologist before construction activities are initiated. The biologist will conduct these activities under the appropriate authorization from the Service and Department (i.e., 10(a)(1)(A) recovery permits or section 7 authorizations to CCWD). The Service will be notified if red-legged frogs are removed and relocated from the

construction corridor within one week following these activities. In occupied sites, the limit of the construction boundary will be fenced to prohibit potential movement of red-legged frogs back into the construction area.

- c. Riparian vegetation that is removed during construction will be restored onsite with the same plant species originally present on the site.
2. Project staging areas will be located at least 250 feet from wetlands and drainages. To the extent feasible, staging areas will be located in existing paved or highly disturbed areas.
 3. All construction vehicles will be kept out of the wetlands that area adjacent to or outside of the immediate construction zone.
 4. Before construction is initiated, fences to control silt or another appropriate sediment control barrier would be placed and maintained along portions of the construction corridor that area adjacent to wetland C-W4 and C-W5 (Fig. 3b).
 5. Bore pits will be excavated at least 25 feet away from riparian vegetation.

Contra Costa Goldfields

The following measures will be implemented to avoid or minimize effects on the goldfields and its habitat resulting from construction.

1. Surveys will be conducted during the proper season before construction to determine if the goldfields is present in wetlands M-W3 through M-W8, M-W11, and M-W12. (Fig. 3a). Survey results will be reported to the Service before project construction is initiated.

If goldfields are confirmed at project sites during surveys, CCWD will implement the following measures:

2. Construction in seasonal wetland areas will occur only during the dry season when wetlands are not ponded with water. This timing varies annually and the allowable construction start date should be determined by a biologist monitoring wetland conditions during spring of the proposed construction year.
3. Construction activities for open-trench pipeline installation (including vegetation and soil removal) will be restricted to a 25-foot-wide zone through seasonal wetlands that

Regional Environmental Manager

24

support goldfields. Construction corridors will be marked to delineate the limits of the allowable construction area.

4. Silt and sediment barriers would be installed along the edge of the construction zone/wetland boundary to prevent sedimentation in adjacent wetlands and drainages.
5. All construction vehicles and materials will be kept out of wetlands that are outside the marked construction zones.
6. Construction areas adjacent to potential habitat will be watered with nontoxic agents to control dust in the vicinity.
7. Topsoil excavated from each wetland area will be stockpiled and reserved for preserve the seedbank endemic to the wetland). Following pipeline installation, any disturbed wetland area will be returned to original grade and topographic contours using the material excavated from the trench.
8. Any permanent loss of occupied habitat resulting from installation of the maintenance road would be compensated through one of the following methods:
 - a. suitable seasonal wetland habitats would be replaced at a ratio of 1.2 acres of created habitat to every one acre of occupied habitat lost. If mitigation credits are not available, habitat would be created as close as feasible to the disturbed site. A habitat creation plan will be prepared which will include site design, grading plans, and soils and planting specifications. Top soil inoculum and seedbank will be collected from the affected wetlands for use in wetland habitat creation. The plan will include a minimum three monitoring and an 80 percent survivorship success for the mitigation site. CCWD will preserve the site in perpetuity;
 - b. if feasible, mitigation credits will be purchased in an approved bank; and
 - c. if costs to replace vernal pool habitats are prohibitive, CCWD will implement a program of replacing vernal pool values through enhancement of existing sites and replace acreage losses through creation of other seasonal wetlands.

Determination of the mitigation method will be made through consultation with the Service and the U.S. Army Corps of Engineers (Corps) through the Clean Water Act 404 process.

Regional Environmental Manager

25

Longhorn Fairy Shrimp, Vernal Pool Tadpole Shrimp and Vernal Pool Fairy Shrimp

The following measures will be implemented to avoid or minimize potential effects on longhorn fairy shrimp, tadpole shrimp and fairy shrimp and their habitat during the construction period:

1. Surveys will be conducted to determine if shrimp are present in wetlands C-W4, C-W5, and C-W6; M-W3 through M-W8; and M-W10 through M-W12 during summer/fall and winter/spring seasons before construction. Survey results will be reported to the Service before project construction is initiated.

If any of the listed shrimp species are confirmed to be present at the project sites during surveys, CCWD will implement the following measures:

2. Construction in seasonal wetland areas would occur only during the dry season when wetlands are not ponded with water. This timing varies annually and the allowable construction start date should be determined by a biologist monitoring wetland conditions during spring of the proposed construction year.
3. Construction activities for open-trench pipeline installation (including vegetation and soil removal) will be restricted to a 25-foot-wide zone through wetlands that support any of the shrimp species. Construction corridors will be marked to delineate the limits of the allowable construction area.
4. Silt and sediment barriers will be installed along the edge of the construction zone/wetland boundary to prevent sedimentation in adjacent wetlands and drainages.
5. All construction vehicles and materials will be kept within the marked construction zone.
6. Construction areas adjacent to potential habitat will be watered with nontoxic agents to control dust in the vicinity.
7. Topsoil excavated from each wetland area will be stockpiled and reserved for subsequent reuse in site restoration of the same wetland area. Following pipeline installation, any disturbed wetland area will be returned to original grade and topographic contours using the material excavated from the trench. Any wetland left bare following construction will be revegetated using pugs of cattail, saltgrass, or other native vegetation obtained from adjacent wetlands.

8. Mitigation for permanent loss of occupied habitat resulting from installation of the maintenance road along the Mallard Pipeline Alignment will be implemented in accordance with the Programmatic Consultation and Biological Opinion (1-1-96-F-132 provided by the Service to the Corps for minor effects on these species from permitted activities in wetland (USFWS 1999). Under this program, habitat loss must be mitigated through preservation and creation of habitat as follows:
 - a. Preservation. For every acre of habitat directly or indirectly affected, two acres of habitat will be dedicated at a Service approved preservation bank (i.e., 2:1 preservation ratio), or three acres will be preserved on the project site (i.e., 3:1 preservation ratio).

Status of the Species:

San Joaquin Kit Fox

The San Joaquin kit fox was federally listed as endangered on March 11, 1967 (32 FR 4001) and State listed as threatened in 1971. For further descriptions of the biology, population status and trends of the kit fox consult the *Recovery Plan for Upland Species of the San Joaquin Valley, California* (USFWS 1998) and the references cited therein

Species Description and Life History. The kit fox is a small canid, with an average body length of 20 inches and weighing about 5 pounds. They are lightly built, with long legs and large ears. Pelage color ranges from tan to buff gray in the summer to silvery gray in the winter. The belly is whitish and the tail is black-tipped.

The diet of kit foxes varies geographically, seasonally and annually, based on temporal and spatial variation in abundance of potential prey. In the southern portion of their range, kangaroo rats (*Dipodomys* spp.), pocket mice (*Perognathus* spp.), white-footed mice (*Peromyscus* spp.), and other nocturnal rodents comprise about one-third or more of their diets. In the northern range, kit foxes prey on California ground squirrels (*Spermophilus beecheyi*), black-tailed hares (*Lepus californicus*), desert cottontails (*Sylvilagus audubonii*), ground-nesting birds, and insects. Dens are used by the kit fox for temperature regulation, shelter from adverse environmental conditions, and escape from predators. Kit foxes excavate their own dens, use those constructed by other animals, and use human-made structures (culverts, abandoned pipelines, and banks in sumps or roadbeds). Kit foxes often change dens and many dens may be used throughout the year. However, evidence that a den is being used by kit foxes may be absent. Kit foxes are subject to competitive exclusion or predation by other species, such as the nonnative red fox (*Vulpes vulpes*), coyote (*Canis latrans*), domestic dog (*Canis familiaris*), bobcat (*Felis rufus*), and large raptors.

Historical and Current Distribution. The current range of the kit fox is divided into two areas, the northern range centering around Contra Costa, Alameda, San Joaquin and Stanislaus counties, and the southern range in the San Joaquin Valley and neighboring valleys. In the San Joaquin Valley before 1930, the San Joaquin kit fox occurred within an 8,700-square mile range in central California from the vicinity of Tracy in the upper San Joaquin Valley on the west side, and near La Grange, Stanislaus County, on the east side, south to the general vicinity of Bakersfield. Historically, kit foxes occurred in several San Joaquin Valley native plant communities: Valley Sink Scrub; Valley Saltbush Scrub; Upper Sonoran Subshrub Scrub; and Annual Grassland. In the northernmost portion of the range, Annual Grassland was most likely the dominant community. By 1958, an estimated 50% of the Valley's original natural communities had been lost, due to extensive land conversions, intensive land uses, and the use of pesticides. Today many of these communities are represented only by small, degraded remnants. Kit foxes are, however, found in grassland and scrubland communities, which have been extensively modified by humans with oil exploration, wind turbines, agricultural practices, and/or grazing. The population is fragmented, particularly in the northern part of the range.

Reasons for Decline and Threats to Survival. Loss and degradation of habitat by agricultural, industrial, and urban developments and associated practices continue to affect kit fox. Loss of habitat contributes to kit fox declines through displacement, direct and indirect mortalities, barriers to movement, and reduction of prey. The isolation of remaining habitat fragments coupled with habitat degradation and barriers to movement, such as aqueducts and highways, can limit dispersal, and threaten survival of kit fox populations (USFWS 1998).

Recovery Actions. In 1998, the *Recovery Plan for Upland Species of the San Joaquin Valley, California* was finalized (USFWS 1998). The plan calls for protecting existing kit fox habitat in the northern, northeastern, and northwestern segment of the geographic range and creating connections between habitat in those areas and habitat further south by managing populations on connecting private and public lands through conservation agreements. Protection of large blocks of lands can best be achieved on a regional basis through the development of HCPs.

Salt Marsh Harvest Mouse

The salt marsh harvest mouse was federally listed as endangered in 1970 (35 FR 1604). A detailed account of the taxonomy, ecology, and biology of the harvest mouse is presented in the approved Recovery Plan for this species (USFWS 1984b). Supplemental information on the status of the harvest mouse is provided below.

Species Description and Life History. Harvest mice are very small rodents, weighing an average of 10 grams. They look very similar to the more widely distributed western harvest mouse (*Reithrodontomys megalotis*). The harvest mouse usually has darker ears and backs, slightly thicker, less pointed and more unicolored tails, and is often darker on the belly. The northern

subspecies of harvest mouse (*R. r. halicoetes*) is found in San Pablo and Suisun Bays, and the southern subspecies (*R. r. raviventris*) is found in the marshes of Corte Madera, Richmond, and south San Francisco Bay.

Harvest mice inhabit both tidal and diked salt marshes in south San Francisco Bay, with these habitat types occurring adjacent to and within salt pond systems. Lock levees, portions of stockpile areas, and vegetated berm adjacent to salt ponds where sufficiently vegetated provide high tide nesting and refugial habitat, which is critical to the survival of harvest mice in tidal habitats. Corridors of diked salt marsh habitat within salt pond systems provide limited salt marsh harvest mouse habitat and, in some situations, may function as corridors between tidal and diked salt marshes.

Primary habitat for the harvest mouse in the north bay historically was tidal pickleweed-dominated salt marsh and brackish marsh in the middle tidal marsh zone, complemented by natural creek levee vegetation (including tall, shrubby gumplants) and upland transition zones supporting vegetation cover which remains emergent even during extreme high tides. Diking for agricultural reclamation eliminated the majority of both habitat components in the San Francisco Bay estuary during the 19th and early 20th century.

Historic and Current Distribution. Harvest mice were probably historically found throughout the San Francisco Bay. Since then, much of the salt marsh habitat necessary for salt marsh harvest mice has been destroyed or degraded, leading to a fragmented distribution. Only a few populations remain.

Reasons for Decline and Threats to Survival. Harvest mice are endangered by loss of habitat and degradation of habitat quality. Substantial populations of harvest mice often occupy diked salt marshes which undergo infrequent episodes of tidal flooding, and irregular periods of inundation from impounded rainwater and runoff from adjacent uplands. These diked salt marshes are subject to large population fluctuations of harvest mice, with "crashes" following periods of prolonged, deep flooding. They provide, however, important refugial populations for the species because most existing salt marsh in the San Francisco Bay estuary is geomorphically young (formed after widespread marsh diking and reclamation), and often lacks the features of mature tidal marsh that supply ample refugia from tidal flooding, such as high densities of natural channel levees and dense, tall gumplant vegetation.

The northern subspecies of harvest mouse has only two extensive, continuous blocks of high quality natural tidal marsh habitat in the North Bay: the wide, protected salt marsh along the north shore of San Pablo Bay from Marin County to Mare Island, Solano County, and the Petaluma Marsh (a natural remnant brackish-salt tidal marsh). The north San Pablo Bay fringing marsh is mostly a monodominant stand of pickleweed, and has recently been modified in Solano County to reduce artificially persistent and deep impoundment of tidal flood waters and rainwater, and to

improve the quality and stability of harvest mouse habitat there. Other harvest mouse habitat in the North Bay consists of relatively small fringing marshes along diked tidal creeks, and diked salt marsh. Virtually all other habitat has been reclaimed for agriculture.

Most recent tidal marsh restoration in the North Bay has produced either low marsh and mudflat, or low-elevation middle marsh (all unsuitable for viable harvest mouse populations), and has contributed relatively little toward the recovery of this species to date. Because of the substantial risk of local extinction associated with infrequent deep, persistent flooding in diked salt marsh, harvest mouse populations are considered to remain at risk in these potential refugial sites. Thus, for most of its range in the North Bay outside the northern San Pablo Bay fringing marshes, the viabilities of most harvest mouse populations remain at a precariously low and uncertain. Mercury accumulation may also be a significant hazard to the harvest mouse.

Recovery Actions. Development of an HCP could assist in restoration or acquisition, through either purchase or placement of conservation easements, of salt marsh habitat along the south side of Suisun Bay within east County. An HCP could also provide funding for feral cat and non-native predator control.

California Least Tern

The least tern was federally protected as endangered on October 13, 1970 (35 FR 16047) without critical habitat. A detailed account of the taxonomy, ecology, and biology of the least tern is presented in the approved Recovery Plan for this species (Service 1980). Supplemental or updated information is provided in the Service's July 16, 1993, biological opinion (Service File No. 1-1-98-F-2) on the Federal Aviation Administration's authorization for proposed facilities improvements at San Diego International Airport, California, which is hereby incorporated by reference. The Service is currently revising the 1980 *California Least Tern Recovery Plan*, which will provide updated species information.

Species Description and Life History. The least tern is the smallest member of the subfamily Sterninae, measuring about 23 cm (bill to tail). The bill is about 27 mm and the total wing length is 45-55 grams. Sex cannot be determined by outward appearance, but can often be told by vocalizations and behavior during the breeding season. (Massey 1976). The "nuptial" plumage is seen during the breeding season and is characterized by a glossy black cap, sharply defined white triangular forehead, pale gray back, pale gray wings except for black outer primaries, yellow bill with a variable black tip (occasionally no black), and reddish-orange legs and feet (Massey & Atwood 1978). This plumage is universal for breeding individuals of both sexes. After the nesting season, as migration approaches, molt and bill-darkening herald the change to winter plumage.

Least terns have not been observed to feed on anything but fish (Massey 1974). Studies on fish dropped at nest sites and observations of food items brought to chicks have resulted in data

pertaining to the size of the type of tern prey. Analyses of these data suggest that size of the prey, rather than the species, is the essential requirement for suitable prey. With the exception of spiny fish (e.g., sculpin), least terns will catch any fish of suitable size. General size characteristics of suitable fish prey include a maximum body depth of 1.2 cm and a maximum body length of about 8 cm. Much smaller fish, often fry, must be taken by adults to feed very small chicks. Most fish taken are apparently younger than 1 year.

Least terns forage primarily in nearshore ocean waters and in shallow estuaries and lagoons. It was assumed in 1973 that least terns feed primarily in estuarine waters, but a study at Huntington Beach, Orange County, in 1979 revealed that adults were feeding primarily in ocean waters, close to shore (Collins et al. 1979). This observation was confirmed a few years later with data from Venice (Los Angeles County), Huntington Beach, and the Santa Margarita River (San Diego County) sites.

At colonies where feeding activities have been studied, the birds foraged mostly within 3.2 km (2 miles) of the breeding area and primarily in nearshore ocean waters less than 18.3 m (60 feet) deep (Collins et al. 1979, Atwood & Minsky 1983). Increased use of coastal freshwater and estuarine habitats has been noted during the chick-feeding and post-fledging periods.

Foraging activity in San Francisco Bay has been found to be more closely associated with the tidal cycle than with time of day (Bailey 1984). By contrast, the time of day was found to be more important than tide level or site at Terminal Island in Los Angeles County (Massey and Atwood 1985).

Historic and Current Distribution. The species breeds in the United States only along the immediate coast of California from San Francisco Bay south to the Mexican border. The breeding population has been distributed in five clusters along the coast, with the heaviest concentration in Los Angeles, Orange and San Diego Counties. From uncountable thousands of breeding pairs, the population was reduced to several hundred by the time of its listing as endangered in 1970. Since listing there has been a focused program, conducted per the Act, to intervene on the tern's behalf and thus protect, enlarge, and restore the species' breeding habitat. During the 25 intervening years, the population has increased to approximately 4,000 breeding pairs. The demographic pattern has not changed; the increase in numbers has been distributed proportionally among the five clusters. Currently, approximately 90% of the breeding pairs nest in southern California. A population model done in conjunction with the recovery planning process indicates that a population of 5000 pairs would give reasonable assurance of continued viability for the next 50 years.

Reasons for Declines and Threats to Survival. Threats to least terns are those actions or lack of action that result in the death or injury of terns or precipitate decreases in their reproduction. The most clearcut threats to the least tern are (and have been): a) climatic events; b) the perturbation,

destruction or pollution of nesting or foraging habitat; c) human intrusion to the extent that prevents successful nesting; d) predation and disease; e) limited potential for habitat expansion; and f) inadequate adaptive management and monitoring of the species.

Recovery Actions. Development of an HCP may provide resources to increase nesting success from development of predator management plans and public awareness of the problem of human disturbance at nesting colonies. The Service is currently revising the 1980 *California Least Tern Recovery Plan* which will provide more specific recovery tasks that can be incorporated into the HCP.

California Clapper Rail

The California clapper rail was federally listed as endangered in 1970 (35 FR 1604). A detailed account of the taxonomy, ecology, and biology of the clapper rail is presented in the approved 1984 Recovery Plan for this species (USFWS 1984b). Supplemental information on the status of the clapper rail, particularly information regarding its status in its northern range, is presented below.

Species Description and Life History. Clapper rails are non-migratory and are year-round residents of San Francisco Bay tidal marshes. In a north San Francisco Bay marsh, Evens and Page (1983) concluded that the breeding season, including pair bonding and nest construction, may begin as early as February. Field observations in south San Francisco Bay marshes suggest that pair formation also may occur in February in some areas. The clapper rail breeding season has two nesting peaks, one between mid-April and early-May and another between late-June and early-July. Harvey (1988) and Foerster *et al.* (1990) reported mean clutch sizes of 7.27 and 7.47 for clapper rails, respectively. The end of the breeding season is typically defined as the end of August, which corresponds with the time when eggs laid during renesting attempts have hatched and young are mobile. Nesting occurs primarily in pickleweed and cordgrass habitat.

Clapper rails forage primarily on benthic invertebrates (Eddleman and Conway 1994; Varoujean 1972; Test and Test 1942; Moffitt 1941; Williams 1929). The non-migratory nature of the clapper rail makes them extremely vulnerable to local contamination. A significant portion of the reported prey includes algal and detrital foragers, and filter feeders, including bivalves (i.e., *Macoma balthica*, *Ischadium demissum*), crabs (i.e., *Pachygrapsus crassipes*), amphipods, and polychaetes (i.e., *Nereis vexillosa*).

Historic and Current Distribution. Of the 193,800 acres of tidal marsh that bordered San Francisco Bay in 1850, about 30,100 acres currently remain (Dedrick 1989). This represents an 84 percent reduction from historical conditions. Furthermore, a number of factors influencing remaining tidal marshes limit their habitat values for clapper rails. Much of the east San Francisco Bay shoreline from San Leandro to Calaveras Point is rapidly eroding, and many marshes along

this shoreline could lose their clapper rail populations in the future, if they have not already. In addition, an estimated 600 acres of former salt marsh along Coyote Creek, Alviso Slough, and Guadalupe Slough, has been converted to fresh- and brackish-water vegetation due to freshwater discharge from south San Francisco Bay wastewater facilities and is of lower quality for clapper rails. This conversion was temporarily stabilized as a result of the drought since the early 1990s.

The suitability of many marshes for clapper rails is further limited, and in some cases precluded, by their small size, fragmentation, and lack of tidal channel systems and other micro-habitat features. These limitations render much of the remaining tidal marsh unsuitable or of low value for the species. In addition, tidal amplitudes are much greater in the south Bay than in San Pablo or Suisun bays (Atwater *et al.* 1979). Consequently, many tidal marshes are completely submerged during high tides and lack sufficient escape habitat, likely resulting in nesting failures and high rates of predation. The reductions in carrying capacity in existing marshes necessitate the restoration of larger tracts of habitat to maintain stable populations.

The clapper rail population is estimated to be approximately 500 to 600 individuals in the southern portion of San Francisco Bay, while a conservative estimate of the north San Francisco Bay population, including Suisun Bay, is 195 to 282 pairs. Historic populations at Humboldt Bay, Elkhorn Slough, and Morro Bay are now extinct; therefore, 30,100 acres of tidal marsh remaining in San Francisco Bay represent the current distribution of this subspecies.

Reasons for Decline and Threats to Survival. As described above, the clapper rail's initial decline resulted from habitat loss and degradation, and reduction in range. Throughout San Francisco Bay, the remaining clapper rail population is besieged by a suite of mammalian and avian predators. At least 12 native and three non-native predator species are known to prey on various life stages of the clapper rail (Albertson 1995). Artificially high local populations of native predators, especially raccoons, result as development occurs in the habitat of these predators around the Bay margins. Encroaching development not only displaces lower order predators from their natural habitat, but also adversely affects higher order predators, such as coyotes, which would normally limit population levels of lower order native and non-native predators, especially red foxes (Albertson 1995).

Hunting intensity and efficiency by raptors on clapper rails also is increased by electric power transmission lines, which criss-cross tidal marshes and provide otherwise-limited hunting perches. Non-native Norway rats (*Rattus norvegicus*) long have been known to be effective predators of clapper rail nests (DeGroot 1927, Harvey 1988, Foerster *et al.* 1990). Placement of shoreline riprap favors rat populations, which results in greater predation pressure on clapper rails in certain marshes. These predation impacts are exacerbated by a reduction in high marsh and natural high tide cover in marshes.

Regional Environmental Manager

33

The proliferation of non-native red foxes into tidal marshes of the south San Francisco Bay since 1986 has had a profound effect on clapper rail populations. As a result of the rapid decline and almost complete elimination of clapper rail populations in certain marshes, the San Francisco Bay National Wildlife Refuge implemented a predator management plan in 1991 (Foerster and Takekawa 1991) with an ultimate goal of increasing rail population levels and nesting success through management of red fox predation. This program has proven successful in increasing the overall south San Francisco Bay populations from an all-time low, however, it has been difficult to effectively conduct predator management over such a large area as the south San Francisco Bay, especially with the many constraints associated with conducting the work in urban environments.

Recovery Actions. Development of an HCP could assist in restoration or acquisition, through either purchase or placement of conservation easements, of salt marsh habitat along the south side of Suisun Bay within east County. An HCP could also provide funding for feral cat and non-native predator control.

California Red-legged Frog

The California red-legged frog was federally listed as threatened on May 23, 1996, (61 FR 25813) effective June 24, 1996. For further descriptions of the biology, population status and trends, and past management of the red-legged frog, consult the final rule (61 FR 25813) and the references cited therein.

Species Description and Life History. The red-legged frog is the largest native frog in the western United States (Wright and Wright 1949), ranging from 4 to 13 centimeters (1.5 to 5.1 inches) in length (Stebbins 1985). The abdomen and hind legs of adults are largely red; the back is characterized by small black flecks and larger irregular dark blotches with indistinct outlines on a brown, gray, olive, or reddish background color. Dorsal spots usually have light centers (Stebbins 1985). Dorsolateral folds are prominent on the back the red-legged frog. Larvae (tadpoles) range from 14 to 80 millimeters (mm) (0.6 to 3.1 inches) in length, and the background color of the body is dark brown and yellow with darker spots (Storer 1925).

Adult red-legged frogs prefer dense, shrubby or emergent riparian vegetation closely associated with deep (>0.7 meters), still, or slow-moving water (Hayes and Jennings 1988). However, red-legged frogs have also been found in ephemeral creeks and drainages and in ponds that may or may not have riparian vegetation. The largest densities of red-legged frogs currently are associated with deep-water pools with dense stands of overhanging willows (*Salix* spp.) and an intermixed fringe of cattails (*Typha latifolia*) (Jennings 1988). Red-legged frogs disperse upstream, downstream, and across uplands, from their breeding habitat to forage and seek shelter. Sheltering habitat is essential for the survival of red-legged frogs within a watershed. Sheltering

habitat, and the ability to reach this habitat can be limiting factors in red-legged frog population numbers and survival.

Female red-legged frogs deposit egg masses on emergent vegetation so that the egg mass floats on the surface of the water (Hayes and Miyamoto 1984). Red-legged frogs breed from November through March with earlier breeding records occurring in southern localities (Storer 1925). Red-legged frogs found in coastal drainages are rarely inactive (Jennings *et al.* 1992), whereas those found in interior sites may hibernate (Storer 1925).

Red-legged frogs lay their eggs during or shortly after large rainfall events in late winter and early spring (Hayes and Miyamoto 1984). Egg masses contain about 2,000 to 5,000 moderate-sized (2.0 to 2.8 mm (0.08 to 0.11 in.) in diameter), dark reddish brown eggs and are typically attached to vertical emergent vegetation, such as bulrushes (*Scirpus* spp.) or cattail (*Typha* spp.) (Jennings *et al.* 1992). Eggs hatch in 6 to 14 days (Jennings 1988). Increased siltation that occurs during the breeding season can cause asphyxiation of eggs and small larvae. Larvae undergo metamorphosis 3.5 to 7 months after hatching (Storer 1925, Wright and Wright 1949, Jennings and Hayes 1990). Of the various life stages, larvae probably experience the highest mortality rates, with less than 1 percent of eggs laid reaching metamorphosis (Jennings *et al.* 1992). Sexual maturity normally is reached at 3 to 4 years of age (Storer 1925, Jennings and Hayes 1985).

The diet of red-legged frogs is highly variable. Hayes and Tennant (1985) found invertebrates to be the most common food items. Vertebrates, such as Pacific tree frogs and California mice (*Peromyscus californicus*), represented over half of the prey mass eaten by larger red-legged frogs (Hayes and Tennant 1985). Hayes and Tennant (1985) found juvenile red-legged frogs to be active diurnally and nocturnally, whereas adult red-legged frogs were largely nocturnal. Feeding activity probably occurs along the shoreline and on the surface of the water (Hayes and Tennant 1985). Larvae likely eat algae (Jennings *et al.* 1992).

Historical and Current Distribution. The frog has been extirpated or nearly extirpated from 70 percent of its former range. Historically, this species was found throughout the Central Valley and Sierra Nevada foothills. At present, red-legged frogs are known to occur in approximately 240 streams or drainages from 23 counties, primarily in central coastal California. The most secure aggregations of red-legged frogs are found in aquatic sites that support substantial riparian and aquatic vegetation and lack exotic predators [e.g., bullfrogs, bass (*Micropterus* spp.), and sunfish (*Lepomis* spp.)]. Threats, such as expansion of exotic predators, proposed residential development, and water storage projects, occur in the majority of drainages known to support red-legged frogs.

The final rule listing the red-legged frog as threatened identifies five geographic areas, called recovery units, which the Service considers vital to the conservation and recovery of the species. In east County red-legged frogs occur in stock ponds in Black Diamond Mines Regional Park, as

well as near Hog Creek, a tributary to Marsh Creek, and in the upper reach of Sand Creek. However, suitable habitat does exist within the project area and lack of sightings may be due to lack of surveys.

Reasons for Decline and Threats to Survival. California red-legged frog populations have declined primarily from habitat loss, over-harvest for human consumption, and the introduction of bullfrogs and various game-fish species that prey or compete with it (Moyle 1973, Stebbins 1983, Hayes and Jennings 1988). Some populations, such as those in the San Joaquin Valley, have been particularly adversely affected by historical reclamation of their wetland habitats and harvest (Jennings and Hayes 1984).

Recovery Actions: Although a recovery plan has not been issued at this time, it is anticipated that the protection of habitat and to protect the watershed integrity will be an integral component for recovery. Habitat protection can be through the purchase of land or conservation easements. Habitat and watershed protection for red-legged frog can be coordinated with the protection of kit fox habitat as there is considerable overlap in habitat types in Contra Costa, Alameda and San Joaquin counties.

Giant Garter Snake

The Service published a proposal to list the giant garter snake as an endangered species on December 27, 1991 (56 FR 67046). The Service reevaluated the status of the giant garter snake before adopting the final rule, and subsequently listed it as a threatened species October 20, 1993 (58 FR 54053).

Species Description and Life History. The giant garter snake is one of the largest garter snakes, reaching a total length of at least 64 inches (160 cm). Females tend to be slightly longer and stouter than males. Dorsal background coloration varies from brownish to olive with a checkered pattern of black spots, separated by a yellow dorsal stripe and two light-colored lateral stripes. Background coloration and prominence of a black checkered pattern and the three yellow stripes are geographically and individually variable (Hansen 1980). The ventral surface is cream to olive or brown and sometimes infused with orange, especially in northern populations.

Endemic to wetlands in the Sacramento and San Joaquin valleys, the giant garter snake inhabits marshes, sloughs, ponds, small lakes, low gradient streams, and other waterways and agricultural wetlands, such as irrigation and drainage Canals and rice fields, and the adjacent uplands. Giant garter snakes feed on small fishes, tadpoles, and frogs (Fitch 1941, Hansen 1980, Hansen 1988). Essential habitat components consist of: (1) adequate water during the snake's active season (early-spring through mid-fall) to provide food and cover; (2) emergent, herbaceous wetland vegetation, such as cattails and bulrushes, for escape cover and foraging habitat during the active season; (3) upland habitat with grassy banks and openings in waterside vegetation for basking;

and (4) higher elevation uplands for cover and refuge from flood waters during the snake's dormant season in the winter (Hansen 1980). Giant garter snakes are typically absent from larger rivers and other water bodies that support introduced populations of large, predatory fish, and from wetlands with sand, gravel, or rock substrates (Hansen 1980, Rossman and Stewart 1987, Brode 1988, Hansen 1988). Riparian woodlands do not provide suitable habitat because of excessive shade, lack of basking sites, and absence of prey populations (Hansen 1980).

The giant garter snake inhabits small mammal burrows and other soil crevices above prevailing flood elevations throughout its winter dormancy period (i.e., November to mid-March). Giant garter snakes typically select burrows with sunny exposure along south and west facing slopes. Giant garter snakes also use burrows as refuge from extreme heat during their active period. The Biological Resources Division (BRD) of the USGS (Wylie *et al.* 1997) has documented giant garter snakes using burrows in the summer as much as 165 feet (50 meters) away from the marsh edge. Overwintering snakes have been documented using burrows as far as 820 feet (250 meters) from the edge of marsh habitat.

During radio-telemetry studies conducted by the BRD giant garter snakes typically moved little from day to day. Snakes have been documented moving up to 5 miles (8 kilometers) over the period of a few days (Wylie *et al.* 1997). In agricultural areas, giant garter snakes were documented using rice fields 19-20% of the observations, marsh habitat 20-23% of observations, and Canal and agricultural waterway habitats 50-56% of the observations (Wylie *et al.* 1997). Within canal and agricultural waterway habitats, giant garter snakes are likely to prefer drainage rather than delivery canals, because drainage canals are often less heavily maintained and are allowed to become vegetated.

The breeding season extends through March and April, and females give birth to live young from late July through early September (Hansen and Hansen 1990). Brood size is variable, ranging from 10 to 46 young, with a mean of 23 (Hansen and Hansen 1990). Young immediately scatter into dense cover and absorb their yolk sacs, after which they begin feeding on their own.

Giant garter snakes are extremely aquatic, are rarely found away from water, forage in the water for food, and will retreat to water to escape predators and disturbance. This species occupies a niche similar to some eastern water snakes (*Nerodia* spp.). Giant garter snakes are active foragers, feeding primarily on aquatic prey such as fish and amphibians. Historically, prey likely consisted of Sacramento blackfish (*Orthodon microlepidotus*), thick-tailed chub (*Gila crassicauda*), and red-legged frog (*Rana aurora*). Because these species are no longer available (chub extinct, red-legged frog extirpated from the Central Valley, blackfish declining/in low numbers), the predominant food items are now introduced species such as carp, mosquitofish, bullfrogs, and Pacific treefrogs (Fitch 1941, Rossman *et al.* 1996).

Historic and Current Distribution - Fitch (1940) described the historical range of the species as extending from the vicinity of Sacramento and Contra Costa Counties southward to Buena Vista Lake, near Bakersfield, in Kern County. Currently, the Service recognizes 13 separate populations of giant garter snake, with each population representing a cluster of discrete locality records (58 FR 54053). The locations of these populations coincide with historical riverine floodbasins and tributary streams throughout the Central Valley. Some of these populations may not be viable because they are small and occur in areas where the quality and extent of habitat are limited. Populations in the Butte, Colusa, Sutter, and American River basins occupy the agricultural water delivery and drainage ditches associated with rice production. Populations in other areas occur in small, isolated patches of habitat. The largest extant population of giant garter snakes inhabits the agricultural channels and ditches in the American River basin at the confluence of the American and Sacramento Rivers (58 FR 54053-54065, October 2, 1993). Giant garter snake populations are declining (California Department of Fish and Game 1994a).

Reasons for Decline and Threats to Survival. Giant garter snake populations have declined primarily from habitat fragmentation and loss to agricultural uses, urban development, and flood control projects (Hansen and Brode 1980). Remaining valley wetland habitats continue to be degraded by toxic chemicals associated with agricultural, industrial, and urban runoff.

Predation may also be an important factor in the giant garter snake's decline. Predatory fish that have been introduced throughout the Central Valley compete with, and prey on, giant garter snakes. The introduction of non-native predatory fish species and the bull frog has reduced the suitability of nearly all permanent and semipermanent waters in the Central Valley (58 FR 54053-54065, October 20, 1993).

Recovery Actions. Development of an HCP could assist in restoration or acquisition, through either purchase or placement of conservation easements, of marsh habitat within Delta of east County.

Alameda whipsnake

The final rule to list the Alameda whipsnake as threatened was published on December 5, 1997 (62 FR 64306). Please refer to the final rule for additional information on the biology and ecology of the whipsnake.

Species Description and Life History. The whipsnake is a member of the family Colubridae (Stebbins 1985). The whipsnake is a slender, fast-moving, diurnal snake with a narrow neck and a relatively broad head with large eyes. The dorsal surface is colored sooty black with a distinct yellow-orange stripe down each side. The anterior portion of the ventral surface is orange-rufous colored, the midsection is cream colored, and the posterior and tail are pinkish. The adults reach a length of 91-122 centimeters (3-4 feet).

The whipsnake is typically found in northern coastal scrub or chaparral plant communities (Omduff 1974), but may also occur in adjacent grasslands and woodlands. Whipsnakes have been shown to travel distances greater than 152.5 meters (500 feet) over grassland to exposed rock outcrops (Swaim pers. comm. 1998). They demonstrate a preference for open-canopy stands and habitats with woody debris and exposed rock outcrops, and they tend to be found on southeast, south, and southwest facing slopes (Swaim 1994). Whipsnakes have been found inhabiting northern exposures in open stands of chaparral (Swaim pers. comm. 1998). Whipsnakes utilize open canopy stands of scrub habitat containing rock outcrops because these habitats provide areas for basking, cover from predators, and an ample source of prey. The whipsnake is a lizard-eating specialist, but its diet may include other prey, such as rattlesnakes and nesting birds, but this depends on the whipsnake's size, sex, age, and location.

Whipsnakes breed from March through June, with mating seeming to occur near the hibernacula of the female (Swaim 1994). Whipsnakes lay clutches of 6 to 11 eggs, May through July (Stebbins 1985), and the young hatch and emerge in the late-summer to early-fall (Swaim 1994).

A number of native and exotic mammals, birds, and reptiles are known or likely to be predators of whipsnake. Snakes have adapted physically and behaviorally to withstand predation levels from these animals. However, in situations where whipsnake habitat has become fragmented, isolated, and otherwise degraded by human activities, increased predatory pressure may become excessive, especially where alien species, such as rats (*Rattus* species), feral pigs (*Sus scrofa*), and feral and domestic cats (*Felis domestica*) and dogs (*Canis familiaris*) are introduced. These additional threats become particularly acute where urban development immediately abuts whipsnake habitat. A growing movement to maintain feral cats in parklands is an additional potential threat to the whipsnake. The EBRPD is currently facing public pressure to allow private individuals to maintain feral cats on park lands (DeVecchio 1997). Although the actual impact of predation under such situations has not been studied, feral cats are known to prey on reptiles, including yellow racers (Hubbs 1951), a fast, diurnal snake closely related to the whipsnake (Stebbins 1985).

McGinnis (1992) has suggested that grazing has impacted the habitat of the whipsnake in many areas east of the Coast Range. Livestock grazing that significantly reduces or eliminates shrub and grass cover can be detrimental to this snake. Many snake species, including the whipsnake, avoid such open areas because of the increased danger from predators and the lack of prey (McGinnis 1992).

Historic and Current Distribution. The whipsnake inhabits the inner coast range in western and central Contra Costa and Alameda counties (Jennings 1983, McGinnis 1992, Swaim 1994). There are five remaining populations with little or no genetic flow between them. The populations are centered in the Sobrante Ridge, Tilden/Wildcat Regional Parks area to the Briones Hills, in Contra Costa County (Tilden-Briones population); the Oakland Hills, Anthony Chabot area to Las Trampas Ridge, in Contra Costa County (Oakland-Las Trampas population);

the Mount Diablo vicinity and the Black Hills, in Contra Costa County (Mount Diablo-Black Hills population); the Wauhab Ridge, Del Valle area to the Cedar Mountain Ridge, in Alameda County (Sunol-Cedar Mountain population); and the Hayward Hills, Palomares area to Pleasanton Ridge, in Alameda County (Hayward-Pleasanton Ridge population).

Reasons for Decline and Threats to Survival. Current threats to whipsnake habitat are increasing urban development and associated impacts, fire suppression and resulting likelihood of catastrophic wildfires, increase predator pressure, and incompatible grazing practices. The central and western portions of Alameda and Contra Costa Counties are highly urbanized and continue to be subjected to increased urbanization. Habitat fragmentation from urban development and associated highway and road construction has led to isolation of the five populations by wholly preventing or severely reducing movement of individuals between areas of suitable habitat. These activities have also reduced the total amount of suitable habitat available for the whipsnake.

Recovery Actions. Development of an HCP could assist in acquisition, through either purchase or placement of conservation easements, of habitat within east County. It could also establish a set of standard avoidance measures for construction or maintenance of fire roads in habitat in east County. An HCP could assist local jurisdictions in developing fire management actions that would also benefit whipsnakes.

Delta smelt

The delta smelt was listed as a threatened species on March 5, 1993 (58 FR 12854). The final rule to list the delta smelt as threatened (58 FR 12854) describes in detail the factors that have contributed to this species' decline. Please refer to final rules 58 FR 12854 and 59 FR 65255 and Department and Reclamation (1994) for additional information on the biology and ecology of the delta smelt.

Species Description and Life History. The delta smelt is a slender-bodied fish with a steely blue sheen on the sides and seems almost translucent (Moyle 1976). The delta smelt, which has a lifespan of one year, has an average length of 60 to 70 mm (about 2 to 3 inches). It is an euryhaline species (tolerant of a wide salinity range) that spawns in fresh water and has been collected from estuarine waters up to 14 parts per thousand (ppt) salinity (Moyle *et al.* 1992). For a large part of its annual life span, this species is associated with the freshwater edge of the mixing zone (saltwater-freshwater interface, also called X2), where the salinity is approximately 2 ppt (Ganssle 1966, Moyle *et al.* 1992, Sweetnam and Stevens 1993).

The delta smelt is adapted to living in the highly productive San Francisco Bay/Delta Estuary (Estuary) where salinity varies spatially and temporally according to tidal cycles and the amount of freshwater inflow. Despite this tremendously variable environment, the historic Estuary

probably offered relatively constant suitable habitat conditions for delta smelt, because they could move upstream or downstream with the mixing zone.

Shortly before spawning, adult delta smelt migrate upstream from the brackish-water habitat associated with the mixing zone in numerous river channels and tidally-influenced backwater sloughs (Radtko 1966, Moyle 1976, Wang 1991). Females with nearly mature eggs were taken at the Central Valley Project (CVP) Tracy Pumping Plant between late December 1990 and April 1991 (Wang 1991). Spawning locations vary widely from year to year (Department and Reclamation 1993). Sampling of larval delta smelt in the Delta suggests spawning has occurred in the Sacramento River; Barker, Lindsey, Cache, Georgiana, Prospect, Beaver, Hog, and Sycamore sloughs; in the San Joaquin River off Bradford Island including Fisherman's Cut; False River along the shore zone between Frank's and Webb tracts; and possibly other areas (Wang 1991). Delta smelt also may spawn north of Suisun Bay in Montezuma and Suisun sloughs and their tributaries.

Delta smelt spawn in shallow, fresh, or slightly brackish water upstream of the mixing zone (Wang 1991). Most spawning occurs in tidally-influenced backwater sloughs and channel edgewaters (Moyle 1976, Wang 1986, 1991, Moyle *et al.* 1992). Although delta smelt spawning behavior has not been observed in the wild (Moyle *et al.* 1992), the adhesive, demersal eggs are thought to attach to substrates such as cattails, tules, tree roots, and submerged branches (Moyle 1976, Wang 1991).

The spawning season varies from year to year and may occur from late winter (December) to early summer (July). Moyle (1976) collected gravid adults from December to April, although ripe delta smelt were most common in February and March. A recent study of delta smelt eggs and larvae (Wang and Brown 1994 as cited in Department and Reclamation 1994) confirmed that spawning occurs from February through June, with a peak in April and May. Spawning has been reported to occur at about 7° to 15° C. Results from a University of California at Davis (UCD) study (Swanson and Cech 1995) indicate that although delta smelt tolerate a wide range of temperatures (<8° C to >25° C), warmer water temperatures restrict their distribution more than colder water temperatures.

Laboratory observations indicate that delta smelt are broadcast spawners that spawn in a current, usually at night (Lindberg 1992 and Mager 1993 as cited in Department and Reclamation 1994). Eggs form an adhesive foot that appears to stick to most surfaces. In these laboratory studies, eggs attached singly to the substrate, with few eggs found on vertical plants and sides of a culture tank (Lindberg 1993 as cited in Department and Reclamation 1994).

Eggs hatched in 9 to 14 days at temperatures from 13° to 16° C during laboratory observations in 1992 (Mager 1992 as cited in Sweetnam and Stevens 1993). In this study, larvae began feeding on phytoplankton on day four, rotifers on day six, and *Artemia nauplii* at day 14. In laboratory

studies, yolk-sac fry were found to be positively phototactic, swimming to the lightest corner of the incubator, and negatively buoyant, actively swimming to the surface. Post-yolk-sac fry were more evenly distributed throughout the water column (Lindberg 1992 as cited in Department and Reclamation 1994). After hatching, larvae and juveniles move downstream toward the mixing zone where they are retained by the vertical circulation of fresh and salt waters (Stevens *et al.* 1990). Pelagic larvae and juveniles feed on zooplankton. When the mixing zone is located in Suisun Bay where there is extensive shallow-water habitat within the euphotic zone (depths less than four meters), high densities of phytoplankton and zooplankton may accumulate (Arthur and Ball 1978, 1979, 1980). Estuarine environments produce an abundance of fish and zooplankton as a result of plentiful food and shallow, productive habitat.

Delta smelt swimming behavior. Observations of delta smelt swimming in the swimming flume and in a large tank show that these fish are unsteady, intermittent, slow-speed swimmers (Swanson and Cech 1995). At low velocities in the swimming flume during spontaneous, unrestricted swimming in a 1-meter tank, delta smelt consistently swam with a "stroke and glide" behavior. This type of swimming is very efficient; Weihs (1974) predicted energy savings of about 50 percent for "stroke and glide" swimming compared to steady swimming. However, the maximum speed delta smelt are able to achieve using this preferred mode of swimming, or gait, is less than 3 body lengths per second, and the fish did not readily or spontaneously swim at this or higher speeds (Swanson and Cech 1995). Juvenile delta smelt proved stronger swimmers than adults. Forced swimming at these speeds in a swimming flume was apparently stressful; the fish were prone to swimming failure and extremely vulnerable to impingement. Unlike fish for which these types of measurements have been made in the past, delta smelt swimming performance was limited by behavioral rather than physiological or metabolic constraints (*e.g.*, metabolic scope for activity; Brett 1976).

Historic and Current Distribution. Delta smelt are endemic to Suisun Bay upstream of San Francisco Bay through the Delta in Contra Costa, Sacramento, San Joaquin, and Solano counties, California. Historically, the delta smelt is thought to have occurred from Suisun Bay upstream to at least the city of Sacramento on the Sacramento River and Mossdale on the San Joaquin River (Moyle *et al.* 1992, Sweetnam and Stevens 1993).

Sacramento splittail

The final rule to list the Sacramento splittail was published on February 8, 1999 (64 FR 5963). For further information on the splittail refer to the final rule.

Species Description and Life History. Splittail were first described in 1854 by W.O. Ayres as *Leuciscus macrolepidotus* and by S.F. Baird and C. Girard as *Pogonichthys inaequilobus*. Although Ayres' species description is accepted, the species was assigned to the genus *Pogonichthys* in recognition of the distinctive characteristics exhibited by the two California

splittail species *P. ciscooides* and *P. macrolepidotus* (Hopkirk 1973). *Pogonichthys ciscooides*, endemic to Clear Lake, Lake County, California, has been extinct since the early 1970s. The splittail represents the only extant species in its genus in California.

The name splittail refers to the distinctive tail of the fish. *Pogon-ichthys* means bearded fish, referring to the small barbels on the mouth of the fish, unusual in North American cyprinids. *Macro-lepidotus* means large-scaled. The splittail is a large cyprinid fish that can exceed 40 centimeters (16 inches) in length (Moyle 1976). Adults are characterized by an elongated body, distinct nuchal hump, and small, blunt head, usually with barbels at the corners of the slightly subterminal mouth. The enlarged dorsal lobe of the caudal fin distinguishes the splittail from other minnows in the Central Valley of California. Splittail are dull, silvery-gold on the sides and olive-gray dorsally. During spawning season, pectoral, pelvic, and caudal fins are tinged with an orange-red color. Males develop small white nuptial tubercles on the head. Breeding tubercles also appear on the base of the fins (Moyle in prep).

In recent times, dams and diversions have increasingly prevented splittail from upstream access to the large rivers, and the species is now restricted to a small portion of its former range (Moyle and Yoshiyama 1992). However, during wet years, they migrate up the Sacramento River as far as the Red Bluff diversion dam in Tehama County, and into the lowermost reaches of the Feather and American Rivers (Moyle in prep, Jones and Stokes 1993, Charles Hanson, State Water Contractors, *in litt.* 1993). Small numbers of splittail have recently been found in the upper Sacramento and San Joaquin rivers and their tributaries (Baxter 1994). Recent surveys of San Joaquin Valley streams found splittail in the San Joaquin River below its confluence with the Merced River, mainly following wet winters (Moyle in prep). Splittail have also been recorded using the Sutter and Yolo Bypasses for spawning areas during wet winters (Sommer *et al.* 1997). Successful spawning has been recorded in the lower Tuolumne River during wet years in the 1980s, as well as in 1995. Both adults and juveniles were observed at Modesto, 11 km upriver from the mouth of the river (Moyle in prep). However, all of the sightings reported above were during wet years when splittail were able to exploit more spawning habitat. Except for very wet years, the species is for the most part now confined to the Delta, Suisun Bay, Suisun Marsh, and Napa Marsh. In the Delta, they are most abundant in the north and west portions when populations are low, but are more evenly distributed throughout the Delta following years of successful reproduction (Sommer *et al.* 1997).

Splittail are relatively long-lived, frequently reaching 5 to 7 years of age. An analysis of hard parts of the splittail indicate that larger fish may be 8 to 10 years old (Moyle in prep). Females are highly fecund, with the largest females producing over 250,000 eggs (Daniels and Moyle 1983). Populations fluctuate annually depending on spawning success, which is highly correlated with freshwater outflow and the availability of shallow-water habitat with submerged vegetation (Daniels and Moyle 1983). Fish usually reach sexual maturity by the end of their second year. The onset of spawning is associated with rising water levels, increasing water temperatures, and increasing day length. Peak spawning occurs from the months of March through May, although

records of spawning exist for late January to early July (Wang 1986). In some years, most spawning may take place within a limited period of time. For instance, in 1995, a year of extraordinarily successful spawning, most splittail spawned over a short period in April, even though larval splittail were captured from February through early July (Moyle in prep). Within each spawning season older fish reproduce first, followed by younger individuals (Caywood 1974). Spawning occurs over flooded vegetation in tidal freshwater and euryhaline habitats of estuarine marshes and sloughs and slow-moving reaches of large rivers. Larvae remain in shallow, weedy areas close to spawning sites for 10 to 14 days and move into deeper water as they mature and swimming ability increases (Wang 1986 and Sommer *et al.* 1997).

Splittail are benthic foragers. In Suisun Marsh, they feed primarily on opossum shrimp (*Neomysis mercedis*, and presumably, the exotic *Acanthomysis* spp. as well), benthic amphipods (*Corophium*), and harpacticoid copepods, although detrital material makes up a large percentage of their stomach contents (Daniels and Moyle 1983). In the Delta, clams, crustaceans, insect larvae, and other invertebrates also are found in the diet. Predators include striped bass (*Morone saxatilis*) and other piscivores (Moyle 1976).

In recent years, splittail have been found most often in slow moving sections of rivers and sloughs and dead-end sloughs (Moyle *et al.* 1992, Daniels and Moyle 1983). Reports from the 1950's, however, mention Sacramento River spawning migrations and catches of splittail during fast tides in Suisun Bay (Caywood 1974). Because they require flooded vegetation for spawning and rearing, splittail are frequently found in areas subject to flooding. Historically, the major flood basins distributed throughout the Sacramento and San Joaquin valleys provided spawning and rearing habitat. These flood basins have all been reclaimed or modified for flood control purposes (e.g., Yolo and Sutter bypasses). Although primarily a freshwater species, splittail can tolerate salinities as high as 10 to 18 parts ppt (Moyle 1976, Moyle and Yoshiyama 1992). The Department's survey data from 1979 through 1994 indicate that the highest abundances occurred in shallow areas of Suisun and Grizzly bays.

Recent research indicates that splittail will use the Yolo and Sutter bypasses during the winter and spring months for foraging and spawning (Sommer *et al.* 1997). However, the Yolo bypass may only be used by splittail during wet winters, when water from Sacramento River over-tops the Fremont Weir and spills over the Sacramento Weir into the bypass. In 1998, the Yolo and Sutter bypasses provided good habitat for fish, particularly splittail, when they were flooded for several weeks in March and April. In order to provide spawning habitat for splittail, water must remain on the bypasses until fish have completed spawning, and larvae are able to swim out on their own, during the draining process.

Historical and Current Distribution. Splittail are endemic to California's Central Valley, where they were once widely distributed (Moyle 1976). Historically, splittail were found as far north as Redding on the Sacramento River (at the Battle Creek Fish Hatchery in Shasta County), as far south as the present-day site of Friant Dam on the San Joaquin River, and up the tributaries of the

Sacramento River as far as the current Oroville Dam site on the Feather River and Folsom Dam site on the American River (Rutter 1908). Recreational anglers in Sacramento reported catches of 50 or more splittail per day prior to the damming of these rivers (Caywood 1974). Splittail were captured in the past in southern San Francisco Bay and at the mouth of Coyote Creek in Santa Clara County, but they are no longer present there (Moyle in prep). The species was part of the Central Valley Native American diet (Caywood 1974).

Vernal Pool Tadpole Shrimp

The tadpole shrimp was listed as endangered on September 19, 1994 (59 FR 48153). Further details on the life history and ecology of the tadpole shrimp are provided by Eng *et al.* (1990) and Simovich *et al.* (1992).

Species Description and Life History. The tadpole shrimp has dorsal compound eyes, a large shield-like carapace that covers most of the body, and a pair of long cercopods at the end of the last abdominal segment (Linder 1952, Longhurst 1955, Pennak 1989). It is primarily a benthic animal that swims with its legs down. Tadpole shrimp climb or scramble over objects, as well as move along or in bottom sediments. Their diet consists of organic detritus and living organisms, such as fairy shrimp and other invertebrates (Pennak 1989). The females deposit their eggs on vegetation and other objects on the pool bottom. Tadpole shrimp populations pass the dry summer months as diapaused eggs in pool sediments. Some of the eggs hatch as the vernal pools are filled with rainwater in the fall and winter of subsequent seasons.

The life history of the tadpole shrimp is linked to the phenology of its vernal pool habitat. After winter rainwater fills the pools, the populations are reestablished from diapaused eggs which lie dormant in the dry pool sediments (Lanaway 1974, Ahl 1991). Ahl (1991) found that eggs in one pool hatched within three weeks of inundation and sexual maturation was reached in another three to four weeks. The eggs are sticky and readily adhere to plant matter and sediment particles (Simovich *et al.* 1992). A portion of the eggs hatch immediately and the rest enter diapause and remain in the soil to hatch during later rainy seasons (Ahl 1991). The vernal pool tadpole shrimp matures slowly and is a long-lived species (Ahl 1991). Adults are often present and reproductive until the pools dry up in the spring (Ahl 1991, Simovich *et al.* 1992).

The genetic characteristics of this species, as well as ecological conditions, such as watershed continuity, indicate that populations of these animals are defined by pool complexes rather than by individual vernal pools (Fugate 1992). Therefore, the most accurate indication of the distribution and abundance of the species is the number of inhabited vernal pool complexes. Individual vernal pools occupied by the species are most appropriately referred to as subpopulations. The pools and, in some cases, pool complexes supporting these species are usually small.

The primary historic dispersal method for the vernal pool tadpole shrimp and likely was large scale flooding resulting from winter and spring rains which allowed the animals to colonize different individual vernal pools and other vernal pool complexes. This dispersal currently is non-functional due to the construction of dams, levees, and other flood control measures, and widespread urbanization within significant portions of the range of this species. Waterfowl and shorebirds likely are now the primary dispersal agents for vernal pool tadpole shrimp (Brusca, in litt., 1992, King, in litt., 1992, Simovich, in litt., 1992). The eggs of these crustaceans are either ingested (Krapu 1974, Swanson *et al.* 1974, Driver 1981, Ahl 1991) and/or adhere to the legs and feathers where they are transported to new habitats.

Tadpole shrimp are restricted to vernal pools/swales, an ephemeral freshwater habitat in California that forms in areas with Mediterranean climates where slight depressions become seasonally saturated or inundated following fall and winter rains. Due to local topography and geology, the pools are usually clustered into pool complexes (Holland and Jain 1988). Tadpole shrimp are not known to occur in permanent bodies of water, riverine waters, or marine waters. Water remains in these pools/swales for a few months at a time, due to an impervious layer such as hardpan, claypan, or basalt beneath the soil surface.

Historic and Current Distribution - Holland (1978) estimated that between 67 and 88 percent of the area within the Central Valley of California which once supported vernal pools had been destroyed by 1973. However, an analysis of this report by the Service revealed apparent arithmetic errors which resulted in a determination that a historic loss between 60 and 85 percent may be more accurate. Regardless, in the ensuing 23 years, threats to this habitat type have continued and resulted in a substantial amount of vernal pool habitat being converted for human uses in spite of Federal regulations implemented to protect wetlands. For example, the Corps' Sacramento District has authorized the filling of 189 hectares (467 acres) of wetlands between 1987 and 1992 pursuant to Nationwide Permit 26 (USFWS 1992). The Service estimates that a majority of these wetland losses within the Central Valley involved vernal pools, the endemic habitat of the vernal pool tadpole shrimp and vernal pool fairy shrimp. Current rapid urbanization and agricultural conversion throughout the ranges of vernal pool tadpole shrimp continue to pose the most severe threats to its continued existence. The Corps' Sacramento District has several thousand vernal pools under its jurisdiction (Coe 1988), which includes most of the known populations of these listed species. It is estimated that within 20 years 60 to 70 percent of these pools will be destroyed by human activities (Coe 1988).

The vernal pool tadpole shrimp is known from 19 populations in the Central Valley, ranging from east of Redding in Shasta County south to Fresno County, and from a single vernal pool complex located on the San Francisco Bay National Wildlife Refuge in Alameda County. It inhabits vernal pools containing clear to highly turbid water, ranging in size from 5 square meters (54 square feet) in the Mather Air Force Base area of Sacramento County, to the 36-hectare (89-acre) Olcott Lake at Jepson Prairie in Solano County. Vernal pools at Jepson Prairie and Vina Plains (Tehama Co.) have a neutral pH, and very low conductivity, total dissolved solids, and alkalinity (Barclay

and Knight 1984, Eng et al. 1990). These pools are located most commonly in grass-bottomed swales of grasslands in old alluvial soils underlain by hardpan or in mud-bottomed claypan pools containing highly turbid water.

Reasons for Decline and Threats to Survival - Tadpole shrimp are imperiled by a variety of human-caused activities, primarily urban development, water supply/flood control projects, and land conversion for agricultural use. Habitat loss occurs from direct destruction and modification of pools due to filling, grading, discing, leveling, and other activities, as well as modification of surrounding uplands which alters vernal pool watersheds. Other activities which adversely affect the species include off-road vehicle use, certain mosquito abatement measures, and pesticide/herbicide use, alterations of vernal pool hydrology, fertilizer and pesticide contamination, activity, invasions of aggressive non-native plants, gravel mining, and contaminated stormwater runoff.

In addition to direct habitat loss, the vernal pool habitat for the tadpole shrimp also has been and continues to be highly fragmented throughout their ranges due to conversion of natural habitat for urban and agricultural uses. This fragmentation results in small isolated tadpole shrimp populations. Ecological theory predicts that such populations will be highly susceptible to extirpation due to chance events, inbreeding depression, or additional environmental disturbance (Gilpin and Soule 1986, Goodman 1987a,b). Should an extirpation event occur in a population that has been fragmented, the opportunities for recolonization would be greatly reduced due to physical (geographical) isolation from other (source) populations.

Only a small proportion of the habitat of tadpole shrimp is protected from these threats. State and local laws and regulations have not been passed to protect the species, and other regulatory mechanisms necessary for the conservation of the habitat of the species have proven ineffective.

Recovery Actions. Development of a regional HCP would allow protection of grasslands that may contain vernal pools not only for vernal pool for for other species allowing for ecosystem protection..

Vernal Pool Fairy Shrimp

The final rule to list vernal pool fairy shrimp as threatened under the Act was published on September 19, 1994 (59 FR 48136). Additional information on the life history and ecology of this species may be found in the final rule,)Eng et al. (1990), Simovich et al. (1992), Helm (1998)). Vernal pool fairy shrimp are restricted to vernal pools, swales, and other seasonal wetlands in California and southern Oregon.

Species Description and Life History. Vernal pool fairy shrimp have delicate elongate bodies; large, stalked, compound eyes; no hard shell (i.e., no carapace); and 11 pairs of swimming legs.

Typically less than 2.5 centimeters (cm) (1 inch) long, they swim or glide gracefully upside-down by means of complex, wavelike beating movements while feeding on algae, bacteria, protozoa, rotifers, and detritus. Female vernal pool fairy shrimp carry eggs in a pear-shaped, ventral brood sac until the eggs are either dropped or sink to the pool bottom with the female when she dies. Eggs which remain after pools dry are known as cysts and are able to withstand heat, cold, and prolonged desiccation. When pools refill in the same or subsequent seasons, some, but not all, of the cysts may hatch, resulting in a cyst bank in the soil that may include cysts from several breeding seasons (Donald 1983). Vernal pool fairy shrimp develop rapidly and may become sexually mature within two weeks after hatching (Helm 1998). Such quick maturation permits fairy shrimp populations to persist in short-lived, shallow bodies of water (Simovich *et al.* 1992).

Vernal pool fairy shrimp inhabit alkaline pools, ephemeral drainages, rock outcrop pools, ditches, stream oxbows, stock ponds, vernal pools, vernal swales, and other seasonal wetlands (Helm 1998). Occupied habitats range in size from rock outcrop pools as small as one square meter to large vernal pools up to 4.5 hectares (11 acres); the depth of occupied habitat ranges from 3 cm (1.2 inches) to 1.2 meters (48 inches).

Historic and Current Distribution. All known populations of vernal pool fairy shrimp inhabit sites in California or southern Oregon. The geographic range of this species encompasses most of--and particularly the eastern side of--the Central Valley from Shasta County to Tulare County and the central coast range from northern Solano County to Santa Barbara County, California; additional disjunct populations have been identified in western Riverside County, California, and in Jackson County, Oregon near the city of Medford (Service 1994, CDFG 1998, Helm pers. com. 1998, Eriksen and Belk 1999).

Reasons for Decline and Threats to Survival. See Vernal Pool Tadpole Shrimp above.

Recovery Actions. See Vernal Pool Tadpole Shrimp above.

Longhorn Fairy Shrimp

Longhorn fairy shrimp are similar in shape and habit to vernal pool fairy shrimp, although they are typically smaller (e.g., 2 cm [0.8 inch]). Female longhorn fairy shrimp carry eggs in a cylindrical, ventral brood sac. The male antennae are relatively long, and have low, wart-like mounds on the medial surface of the distal end of their basal segments (Eng *et al.* 1990, Eriksen and Belk 1999).

Longhorn fairy shrimp generally inhabit moderately deep, medium to large-sized grass-bottomed and clay-bottomed alkaline pools and moderately deep, small to medium-sized rock outcrop pools (Eng *et al.* 1990, Helm 1998); however, individuals have been observed in pools less than one square meter (0.0002 acre) in area to pools as large as 0.3 hectares (0.7 acre). The depth of known, occupied habitats ranges from 20 cm (8 inches) to 51 cm (20 inches).

All known populations of longhorn fairy shrimp inhabit sites in California. The geographic range of this species encompasses the western San Joaquin Valley and the eastern flank of the central and southern coastal range (CDFG 1998, Eriksen and Belk 1999). Based on the geographic range of this species, the Service considers appropriate habitats in the following counties to potentially support longhorn fairy shrimp: Alameda, Contra Costa, western Fresno, western Kern, Kings, western Madera, Merced, eastern Monterey, San Benito, San Joaquin, eastern San Luis Obispo, Santa Clara, and Stanislaus.

Reasons for Decline and Threats to Survival. See Vernal Pool Tadpole Shrimp above.

Recovery Actions. See Vernal Pool Tadpole Shrimp above.

Contra Costa goldfields

Contra Costa goldfields was listed as endangered on June 18, 1997 (62 FR 33029).

Species Description and Life History. It is a showy spring annual in the aster family (Asteraceae) that grows 10 to 30 centimeters (4 to 12 inches) tall and is usually branched. The leaves are opposite, light green, and usually have a feather-like arrangement with narrow clefts extending more than halfway toward the stem. The flowers are found in terminal yellow heads. The reduced leaf-like structures at the base of the flower (phyllaries) are one-third to one-half fused; the small, dry, fruits with a single chamber (achenes) are less than 1.5 millimeters (0.06 inches) long and always lack a modified outer floral structure at the end of the fruit (pappus). Goldfields flowers from March to June. The partially fused phyllaries and the lack of a pappus distinguish this species from *L. fremontii* and *L. burkei*, which it otherwise closely resembles.

Habitat for goldfields consists of vernal pools in open grassy areas of woodland and valley grassland communities. Vernal pools are a natural habitat type of the Mediterranean climate region of the Pacific coast and the Central Valley of California. Covered by shallow water for extended periods during the cool season but completely dry for most of the warm season drought, vernal pools hold water long enough to allow some purely aquatic organisms to grow and reproduce, but not long enough to permit the development of a typical pond or marsh ecosystem. The alternation of very wet and very dry conditions creates an unusual ecological situation that supports a unique biota (Zedler 1987). Dains (1995) has suggested that goldfields plants prefer shallow vernal pools or vernal pool margins, and that the species' range of habitat includes marginal use of somewhat alkaline soils. Alkalinity and salinity were not distinguished in her study. Dains also reported that ryegrass (*Lolium multiflorum*) and other common non-native species can out-compete goldfields in the absence of grazing.

Historic and Current Distribution. Historically, the species grew in vernal pools in seven counties—Alameda, Contra Costa, Mendocino, Santa Barbara, Santa Clara, Napa, and Solano

Counties, California. It has been extirpated from Mendocino, Santa Barbara, and Santa Clara Counties, by agricultural land conversion, urbanization, and creek channelization. Goldfields is now found in approximately 14 localized populations occurring in four general areas of Alameda, Contra Costa, Napa, and Solano Counties (California Native Plant Society (CNPS) 1978, California Natural Diversity Database (CNDDDB) 1998). One population occurs in the County; two in Napa County; and two in Alameda County. One population was discovered in Monterey County in 1998. In 1995, approximately 1,000 plants were found adjacent to the FWSI project area near the headwaters of Rodeo Creek, just north of State Route 4. Nine populations are located in Solano County and some of the populations are clustered near the town of Fairfield. With the exception of the population found on San Francisco National Wildlife Refuge in Alameda County and the one on Fort Ord, in Monterey County, all populations are threatened.

Reasons for Decline and Threats to Survival - Degradation to goldfields habitat may result from long-term human disturbance, after any nearby residential and industrial areas are developed, through impacts from herbicide or pesticide use, trash dumping, and uncontrolled off-road vehicle use. Off-road vehicle use and other recreational activities associated with humans can lead to wheel ruts, soil compaction, increased siltation, destruction of native vegetation, introduction of non-native vegetation, and an alteration of pool hydrology.

All of the 11 populations north of San Pablo and Suisun Bays are found on sites that are proposed for development or agricultural land conversion. Because of the small number of populations of this species, protection of all remaining populations is necessary for the species' survival. Loss of any population would significantly reduce the range of the species and would reduce the amount of genetic material available which is critical for restoration and recovery activities. Any changes in the amounts or durations of inundation of the habitat can affect the reproductive success of the species present. Erosion associated with construction can contaminate vernal pool habitat through the transport and deposition of sediments into these areas. Thus, effects of runoff from impervious surfaces need to be avoided.

Recovery Action. The development of an HCP could benefit goldfields by identifying additional populations, if any, and protecting the existing population at the headwaters of Rodeo Creek through land purchase or placing a conservation easement over properties where they occur.

Soft bird's-beak

On June 12, 1995, the Service published a proposed rule to list soft bird's-beak (*Cordylanthus mollis* ssp. *mollis*) as endangered (60 FR 31000). On November 20, 1997, the Service published a final rule determined endangered status for soft bird's-beak (62 FR 61916).

Species Description and Life History. Soft bird's-beak is an annual herb of the snapdragon family (Scrophulariaceae) and the individual plants grow 25 to 40 centimeters (10 to 16 inches) tall. It is

sparingly branched from the middle and above. The foliage is grayish-green (often tinged a deep red) and hairy. The oblong to lance-shaped leaves are 1.0 to 2.5 centimeters (0.4 to 1.0 inch) long, the lower leaves entire and the upper with one to three pairs of leaf lobes. The inflorescence consists of spikes 5 to 15 centimeters (2 to 6 inches) long. A floral bract with two to three pairs of lobes occurs immediately below each inconspicuous white or yellowish-white flower. Soft bird's-beak flowers between July and-September.

Soft bird's-beak is found predominantly in the upper reaches of salt grass-pickleweed marshes at or near the limits of tidal action. It is associated with pickleweed (*Salicornia virginica*), saltgrass (*Distichlis spicata*), fleshy jaumea (*Jaumea carnosa*), alkali heath (*Frankenia salina*), and seaside arrow-grass (*Triglochin maritima*).

Historic and Current Distribution. Ten disjunct occurrences of soft bird's-beak are widely scattered throughout coastal salt or brackish tidal marshes fringing San Pablo and Suisun Bays, in Contra Costa, Napa and Solano Counties (CNDDDB 1997). The total number of individuals reported among populations varies from 1 at the smallest site to 141,000 plants at the largest site. Most sites have between 1,000 to 6,000 individuals (CNDDDB 1997). The species has been extirpated from Marin and Sonoma Counties.

Reasons for Decline and Threats to Survival. Approximately 15 percent, 12,142 hectares (30,002 acres), of the historical tidal marshland habitat within the San Francisco Bay area remains (Dedrick 1989). In San Pablo Bay, historical tidal wetlands have been diked and converted to agricultural lands that were farmed for oat hay. In addition, approximately 4,050 hectares (10,000 acres) also were converted to salt ponds. In Suisun Bay, most of the 28,780 hectares (71,100 acres) of tidal marshes that existed in 1850 were converted originally to agricultural land, and then to diked seasonal wetlands used for waterfowl management. Only 3,780-hectares (9,340 acres) within Suisun Marsh remain as tidal marsh (Dedrick 1989). Most of the remaining tidal marshes are backed by steep levees, allowing for little or no transitional wetland habitat that is needed for soft bird's-beak. Habitat conversion, water pollution, upstream withdrawals of fresh water, erosion, mosquito abatement activities, projects that alter natural tidal regime, and foot traffic threaten soft bird's-beak (CNDDDB 1997).

Recovery Action. Implementation of an HCP could facilitate protection by including agencies, such as Mosquito Abatement, whose activities may impact soft bird's beak. Protective actions that can be taken by the development community could be incorporated into the HCP.

Environmental Baseline

The environmental baseline used in this analysis includes past and ongoing impacts of all Federal, State, Tribal, and private actions and other human activities in the vicinity of the project that have

impacted, or are impacting the listed species. The action area of the proposed project is generally north central and eastern County.

The project area is located in north central and east County. It is bordered by Suisun Bay and the San Joaquin River on the north and the Delta on the northeast. CCWD has diversion facilities on Old River near Highway 4, at Rock Slough and at Mallard Slough. The project area encompasses approximately 120,657 acres (not including 19,500 acres of open-water habitat Bay-Delta channels), of which slightly more than half are developed. Approximately two thirds of the undeveloped acres are designated for open space or agricultural uses on county and city general plans. The distribution of project area acreage by habitat type is shown on the following table.

San Joaquin Kit Fox

Sightings of kit fox in the northern portion of their range are sporadic and are frequently unreported. However, within the last few years kit foxes have been reported at Black Diamond Preserve and south of the Contra Loma Regional Parks. The project area is contiguous with known occupied habitat.

In 1993, the Service issued a biological opinion (1-1-92-F-48) to Reclamation on the construction and operating effects of CCWD's LV Reservoir on fox and bald eagle in the County. LV Reservoir is located approximately seven miles south of Brentwood in an unincorporated area of the County. The project incorporates approximately 19,000 acres of land. The reservoir inundates approximately 1,460 acres. Approximately 6,500 acres of these lands are managed as specified management lands for listed species. This includes, but is not limited to, modifying grazing and rodenticide practices enhancing grasslands for kit fox. Although management of the entire watershed is primarily to protect water quality, direct and indirect actions to protect water quality will also benefit kit foxes and red-legged frogs.

Habitat loss is the primary cause of the decline of the kit fox in the northern portion of its range. Most of the preferred valley bottom grassland and alkali scrub habitats in the northern range have been eliminated by agricultural, suburban, and industrial development (USFWS 1998). Urban development with Antioch, Pittsburgh and Brentwood continue to remove large blocks of grasslands that could be utilized by kit foxes. Adjacent to Black Diamond Regional Preserve, the Roddy Ranch project converted several hundred acres of grassland to a golf course. In Antioch, Future Urban Area 1 will remove thousands of acres of denning and foraging habitat. In Brentwood, urban development on Balfour Road continues to encroach into grasslands reducing the amount of available foraging and denning habitat as well as increasing the likelihood of vehicle strikes. Increased visitation to local parklands from people can impact kit foxes as some of these parks do not have leash requirements in undeveloped portions of the park. People abandoned cats in these parks and subsequently feral cat populations become established.

Regional Environmental Manager

52

Salt Marsh Harvest Mouse

The status of the salt marsh harvest mouse populations in the FWSI project area is undetermined. The species has been observed in and near the project area, including observations from the Avon-Port Chicago Marsh, between Benicia-Martinez Bridge and Pacheco Creek-Avon Refinery, and marshlands west of Antioch.

California Least Tern

Two nesting colonies are present in the FWSI project area. One nesting colony is located at the PG&E plant in Pittsburg and the second is located at the Avon-Port Chicago Marsh. Birds from these colonies forage in the adjacent Delta waterways. It is doubtful that other nesting locations occur in the project area because potentially suitable nesting habitat is limited and subject to human disturbances associated with urban, industrial and recreational activity.

California Red-Legged Frog

Suitable red-legged frog habitat is present in the FWSI project area. Red-legged frogs could occur in permanent and intermittent streams, ponds and wetlands found in this area. They may utilize adjacent grasslands and riparian habitats for summer estivation and for dispersal.

All locations of red-legged frog populations within the project area have not been determined, but there are several records of the species occurring within CCWD/LVP Service Areas. Frogs have been observed at the Black Diamond Mines Regional Park; Markley Canyon Creek, west of Pittsburg; south of Willow Pass Road and State Route 4; Keller Canyon, southwest of Pittsburg; and Marsh Creek, southwest of Clayton. They also occupy intermittent and permanent stream and pond habitats at Los Vaqueros, south of the FWSI project area (Jones & Stokes Associates 1996).

As discussed above, the LV project incorporates approximately 19,000 acres of land. Approximately 6,500 acres of these lands are managed as specified management lands for listed species and includes creating or enhancing approximately 10.5 acres of stockponds and restoring the riparian vegetation along Kellogg Creek to benefit red-legged frogs.

Loss and degradation by agricultural, industrial and urban development and associated practices continue to affect red-legged frogs. Loss of riparian habitat through channelization for flood control has reduced available habitat and reproductive opportunities. Development of surrounding grasslands has reduced the opportunity for juveniles and breeding adults to disperse into other available habitat. Many of the same project impacts that effect kit foxes also effect red-legged frogs.

Regional Environmental Manager

53

Giant Garter Snake

The status of the giant garter snake in the project area is undetermined. One sighting has been reported near the north end of the Antioch Bridge. Suitable habitat appears to be present within the FWSI project area, but is most likely limited to freshwater marshes in the Delta, east of the Antioch Bridge.

Alameda Whipsnake

The whipsnake is present within the FWSI project area, but the status of populations in this area is undetermined. The species is known to occur in the LV watershed (Jones & Stokes Associates 1996), Round Valley Regional Park, Black Diamond Mines Regional Park, and in the Mount Diablo area.

Vegetation management techniques for the prevention of wildfires have submitted by CCWD, East Bay Regional Parks District, and Mt. Diablo State Parks. These plans are currently being review by the Service. Vegetation management techniques include hand clearing of chaparral, prescribed burns and construction of fire breaks. Of all these techniques, conducting prescribed burns may be most beneficial to whipsnakes over the long term as it may have additional benefits to the chaparral community. However, conducting prescribed burns in the future will become increasingly difficult as urban development encroaches into open space areas for fear that fires will burn out of control. Conversely, the incident of wildfires will increase as urban development encroaches as numerous wildfires are the result of human activities.

Delta smelt

Adult delta smelt spawn in central Delta sloughs from February through August in shallow water areas having submersed aquatic plants and other suitable substrates and refugia. These shallow water areas have been identified in the Delta Native Fishes Recovery Plan (Recovery Plan) (Service 1996) as essential to the long-term survival and recovery of delta smelt and other resident fish. A no net loss strategy of delta smelt population and habitat is proposed in this Recovery Plan.

Delta smelt are adapted to living in the highly productive Estuary where salinity varies spatially and temporally according to tidal cycles and the amount of freshwater inflow. Despite this tremendously variable environment, the historical Estuary probably offered relatively consistent spring transport flows that moved delta smelt juveniles and larvae downstream to the mixing zone. Since the 1850's, however, the amount and extent of suitable habitat for the delta smelt has declined dramatically. The advent in 1853 of hydraulic mining in the Sacramento and San Joaquin rivers led to increased siltation and alteration of the circulation patterns of the Estuary (Nichols *et al.* 1986, Monroe and Kelly 1992). The reclamation of Merritt Island for agricultural purposes, in

the same year, marked the beginning of the present-day cumulative loss of 94 percent of the Estuary's tidal marshes (Nichols *et al.* 1986, Monroe and Kelly 1992).

In addition to the degradation and loss of Estuarine habitat, the Delta smelt have been increasingly subject to entrainment, upstream or reverse flows of waters in the Delta and San Joaquin River, and constriction of low salinity habitat to deep-water river channels of the interior Delta (Moyle *et al.* 1992). These adverse conditions are primarily a result of drought and the steadily increasing proportion of river flow being diverted from the Delta by the CVP and State Water Project (SWP) (Monroe and Kelly 1992). There is a correlation between the proportion of delta smelt that reside in Suisun Bay and overall abundance. This relationship indicates that the summer townet index increased dramatically when outflow was between 34,000 and 48,000 cfs which placed X2 between Chipps and Roe islands. Placement of X2 downstream of the Confluence, Chipps and Roe islands provides delta smelt with low salinity and protection from entrainment, allowing for productive rearing habitat that increases both smelt abundance and distribution.

The results of seven surveys conducted by the Interagency Ecological Program (IEP) corroborate the dramatic decline in delta smelt attributable to baseline conditions. Existing operations were meant to provide sufficient Delta outflows from February 1 through June 30 to transport larval and juvenile delta smelt out of the "zone of influence" of the CVP and SWP pumps, and provide them low salinity, productive rearing habitat. This zone of influence has been delineated by Water Resources's Particle Tracking Model and expands or contracts with CVP and SWP combined pumping increases or decreases, respectively (Department and Reclamation 1993). Tidal action may enhance the hydraulic effects of exports which in turn may effect larvae and juveniles as far west as the Confluence.

According to seven abundance indices which provide information on the status of the delta smelt, this species was consistently at low population levels through the 1980's (Stevens *et al.* 1990). These same indices also showed a pronounced decline from historical levels of abundance (Stevens *et al.* 1990).

Specifically, the summer townet abundance index constitutes one of the more representative indices because the data have been collected over a wide geographic area (from San Pablo Bay upstream through most of the Delta) for the longest period of time (since 1959). The summer townet abundance index measures the abundance and distribution of juvenile delta smelt and provides data on the recruitment potential of the species. Since 1983, (except for 1986, 1993, and 1994), this index has remained at consistently lower levels than previously found. These consistently lower levels correlate with the 1983 to 1992 mean location of X2 upstream of the Confluence, Chipps and Roe islands.

The second longest running survey (since 1967), the fall midwater trawl survey (FMWT), measures the abundance and distribution of late juveniles and adult delta smelt in a large

geographic area from San Pablo Bay upstream to Rio Vista on the Sacramento River and Stockton on the San Joaquin River (Stevens *et al.* 1990). The fall midwater trawl indicates the abundance of the adult population just prior to upstream spawning migration. The index that is calculated from the FMWT survey uses numbers of sampled fish multiplied by a factor related to the volume of the area sampled. Until recently, except for 1991, this index has declined irregularly over the past 20 years (CDFG unpublished data, 1999). Since 1983, the delta smelt population has exhibited more low fall midwater trawl abundance indices, for more consecutive years, than previously recorded. The 1994 FMWT index of 101.7 was a continuation of this trend. This occurred despite the high 1994 summer townet index for reasons unknown. The 1995 summer townet was a low index value of 319 but resulted in a high FMWT index of 898.7 reflecting the benefits of large transport and habitat maintenance flows due to an extremely wet year.

The FMWT abundance index (128.3) for 1996 represented the fourth lowest on record. For 1997, the abundance index (360.8) almost tripled over last years results. In 1998, the summer townet index was 3.3 and the fall index was 417.6, which was up slightly from the 1997 index. Recovery criteria, including both abundance and distribution criteria based on numbers derived from the FMWT, have not been met to date. This indicates that delta smelt are not moving toward recovery.

During May and June of 1999, over 100,000 delta smelt were incidentally taken at the export facilities. However, none were found to have entered CCWD's intake at Old River during the period the pump plant was operating. (Pursuant to the operations plan and the LV biological opinion, there were no diversions during two weeks of the period in question; however, when diversions resumed, no smelt were found to pass through the screen in the monitoring program. This is clearly not a function of the scale of diversion: at the same time no smelt were taken while CCWD was pumping 250 cfs, thousands were taken at Banks Pump Plant where the pumping was 850 cfs). This would indicate that the protection afforded by CCWD's new intake greatly exceeds that assumed in the studies used in the LV biological opinion. The allocated incidental take for those two months is 20,478. Delta smelt remained in the Delta for an extended period of time this past spring. It was hypothesized that it was a result of cooler water temperatures. The final summer townet index for 1999 is 11.9, an increase from the 1998 index of 3.3. However, this is still below the pre-decline average of 20.4 (1959-1981, no sampling 66-68). The FMWT index for September is 198, whereas for September 1998 it was 239. The data is inconclusive at this point, until the remaining indices are calculated for the FMWT.

The March 6, 1995, and the February 12, 1993, (delta smelt and winter-run, respectively) biological opinions on the effects of long-term operation of the CVP and the SWP coupled with the October 13, 1981, Corps export pumping guidance, and the November 2, 1994, biological opinion on the Environmental Protection Agency's proposed Water Quality Standards for the San Francisco Bay/Sacramento-San Joaquin Rivers and Delta have, in conjunction with the 1995 Water Quality Control Plan and a statutory mandate pursuant to Section 3406(b)2 of the CVP

Improvement Act to manage 800 TAF of water for fish and wildlife purposes, established the current environmental baseline for delta smelt and splittail. Part of this environmental baseline requires Delta outflows between February 1 to June 30 to transport larval and juvenile delta smelt out of the "zone of influence" of the CVP and SWP export pumps and maintain the location of X2 at or downstream of three distinct points: the confluence of the Sacramento and San Joaquin rivers, Chipps Island, and Roe Island. The length of time X2 must be positioned at these set locations in each month is determined by a formula that considers the previous month's inflow to the Delta and a "Level of Development" factor, denoted by a particular year.

Compliance with the salinity criteria at Roe and Chipps islands can be achieved in any one of the following three ways: (1) the daily salinity value meets the requirement, (2) the system is operated on that day so as to meet the "flow equivalent," or (3) by using a 14-day moving average. The use of the 14-day moving average allows the mean location to be achieved despite the varying strength of tidal currents during the lunar cycle because any 14 day period would include the full range of spring and neap tidal conditions. Meeting the confluence standard can be achieved by meeting either implementation scheme 1 or 3 above.

Delta modeling conducted by a variety of individuals and agencies analyzed approximately 73 years of hydrologic data from the Sacramento/San Joaquin rivers and Delta. The analysis shows the average position of X2 was either downstream of the targeted compliance point or has met the compliance point through an increase in the number of days in many of these years. This compliance point has been maintained mainly because the export facilities have not had the ability to capture all of the unimpaired run-off and, thus, have been well below the Export-Inflow Ratio. Therefore, the Service was able to provide the CVP and SWP with a non-jeopardy biological opinion on the long-term operation of their projects. Additionally, the Service anticipated that the estuarine conditions for delta smelt would be improved by (1) the signing of the Framework Agreement that would require the CVP and SWP to make an equitable contribution to meet the revised water quality standards, (2) the obligation of Federal agencies carrying out programs for the conservation (recovery) of listed species as imposed by section 7 of the Act, and (3) the scheduled renewal or reopening of water contracts and licenses that would provide an additional opportunity to implement Recovery Plan objectives. Collectively, these actions would result in phased improvement to water quality-based habitat requirements.

Due to subsequent wet years, the regulatory requirements have been met every year since 1995. The CVP/SWP were able to meet the compliance point for X2. They also did not need to manage the system to the E/I ratio all of the time. If these excellent environmental parameters are maintained over time, the species could be heading toward recovery. However, these benefits are offset by the endless new projects that are being proposed. Therefore, rather than improving the environmental baseline with these good water years, it is being maintained.

The Service issued a non-jeopardy biological opinion (1-1-95-F-110) for the Delta Wetlands Project after significant negotiations and changes to the proposed project description. The original

project description significantly degraded the estuarine conditions by adversely affecting Delta hydrology and causing incremental up-stream shifts of X2. The Delta Wetlands Project, as modified, including conditions to minimize up-stream shifts of X2 and adverse effects to Delta hydrology within the action area. The Service issued a draft jeopardy biological opinion for the Interim South Delta Program as the original project significantly degraded the estuarine conditions by adversely affecting Delta hydrology and causing incremental up-stream shifts of X2.

Other projects currently under Service review include the Sacramento County Water Contract Renewal, and East Bay Municipal Utility District Contract Renewal. These projects likely would result in a deterioration of the environmental baseline, causing X2 to incrementally move up-stream if allowed to go forward as proposed. Allowing these projects to proceed as proposed would incrementally degrade current baseline conditions. Degradation of the environmental baseline may be significantly affect recovery and survival of these species.

Sacramento splittail

The decline in splittail abundance has taken place during a period of increased human-induced changes to the seasonal hydrology of the Delta, especially the increased exports of freshwater from the Delta and increased diversions of water to storage. These changes include alterations in the temporal, spatial, and relative ratios of water diverted from the system. These hydrological effects, coupled with severe drought years, introduced aquatic species, the loss of shallow-water habitat to reclamation activities, and other human-caused actions, have reduced the species' capacity to recover from natural seasonal fluctuations in hydrology for which it was adapted.

Analyses of survey data collected from 1967 to 1993 (Meng 1993, Meng and Moyle 1995), and data from 1967 to 1997 by the Service, CDFG, University of California at Davis, and biologists from several different studies the following trends:

(1) Overall, splittail abundance indices have declined. Meng and Moyle (1995) demonstrated that on average, splittail have declined in abundance by 60 percent through 1993. These data were updated by the CDFG to include the most current data available. The Service conducted the statistical analysis using the updated information. The results were similar. These updated data demonstrate that on average, splittail have declined significantly in abundance by 50 percent since 1984. The greatest declines (over 80 percent) were found from studies that sampled the shallow Suisun Bay area, the center of the range of the species (Meng and Moyle 1995). The updated information also shows a significant decline (43 percent) for the studies that sampled the shallow Suisun Bay area. The Bay study that began in 1980 in the lower Estuary, at the outermost edge of splittail range, found the lowest percent decline (20 percent) (CDFG, unpublished data) through 1993. The Bay study analysis completed on the updated data also showed the smallest decline for study (6 percent). The number of splittail young taken at State and Federal pumping facilities (per acre-foot of water pumped), as of 1993, had declined 64 percent since 1984. With the updated

data, the number of splittail young taken at State and Federal pumping facilities demonstrated a 97 percent increase. This percent increase is due to the unusually high salvage that occurred during 1995.

Splittail populations are estimated to be 35 to 60 percent of what they were in the 1940's, and these estimates may be conservative (Moyle in prep). Department midwater trawl data indicate a decline from the mid-1960s to the late 1970s, followed by a resurgence, with yearly fluctuations, through the mid-1980s. From the mid-1980s through 1994, splittail numbers have declined in the Delta, with some small increases in various years. This decline is also demonstrated in the updated Department data.

(2) Overall splittail abundances vary widely between years. Sommer *et al.* 1997 also found that splittail recruitment success fluctuates widely from year to year and over long periods of time. During dry years abundance is typically low. During the dry years of 1980, 1984, 1987, and 1988 through 1992, splittail abundance indices for young-of-the-year were low, indicating poor spawning success. Additionally, all year class abundances were low during these years. In 1994, the fourth driest year on record, all splittail indices were extremely low.

Wet years are assumed to provide essential habitat for splittail and allow populations to rebound from dry years. Successful reproduction in splittail is often highly correlated with wet years. Large pulses of young fish were observed in wet years 1982, 1983, 1986, and 1995. In 1995, one of the wettest years in recent history, an increase in all indices was recorded, as in 1986, which was another wet year following a dry year. However, young of the year taken per unit effort (for example, either the number of fish per net that is towed or the number of fish per volume of water sampled) has actually declined in wet years, from a high of 12.3 in 1978 to 0.3 in 1993. The updated data from CDFG demonstrate this same decline in wet years, from 37.3 in 1978 to 0.6 in 1993. The abundance indices of splittail during the years of 1995, 1996, and 1997 were 44.5, 2.1, and 2.6, respectively. In 1995, a very wet year, splittail abundances were high. However in 1996 and 1997, both wet years, abundance indices were low. 1998 was a wet year with a large splittail year class produced. However, overall splittail declines remain high (82 percent/43 percent with updated data) in the shallow-water Suisun Bay area, the center of its distribution..

(3) A strong relationship exists between young-of-the-year abundance and outflow (i.e., river outflow into San Francisco Bay after water exports are removed). As outflow increases, annual abundance of young-of-the-year splittail increases. Changes in outflow explain 55 to 72 percent of the changes seen in young-of-the-year splittail abundance, depending on which survey data are analyzed.

(4) Splittail are most abundant in shallow areas of Suisun and Grizzly bays where they generally prefer low-salinity habitats. Salinities in Suisun and Grizzly bays increase when, as a result of

water exports or drought conditions, the mixing zone (the freshwater-saltwater interface) shifts upstream.

(5) Concentration of splittail in shallow areas suggests that they are particularly vulnerable to reclamation activities, such as dredging, diking, and filling of wetlands. The above data indicate that splittail abundances vary widely in response to environmental conditions, but the general population numbers are declining.

Changes in water diversions are most likely at the SWP. For the most part, the Federal pumping plant has operated at capacity for many years (pumping at rates up to 4,600 cfs), so increased exports at this plant are unlikely. However, the SWP pumping plant and the State Aqueduct have considerable unused capacity. The SWP currently pumps at rates up to 6,400 cfs and plans to increase pumping rates by more than 50 percent. Local private water diverters are relatively stable and export up to 5,000 cfs from about 1,800 diversions scattered throughout the Delta. The DWR (1992) reported past and projected SWP deliveries from Delta sources during the years of 1962 to 2035. In the 1980's, deliveries ranged from 1.5 million acre-feet to 2.8 million acre-feet. By 2010, deliveries of up to 4.2 million acre-feet are planned.

If the exceedingly high take (millions of fish) at the export facilities that occurred in 1995 continues to occur in other wet years, the species may be precluded from recovery. In a good year such as 1995, splittail spawn in prolific numbers. These good years are needed to maintain the population of splittail in the Delta. However, the high take that occurs during these years, offsets the benefits that a strong year class may provide.

Longhorn Fairy Shrimp, Vernal Pool Tadpole Shrimp and Vernal Pool Fairy Shrimp

There are no recorded observations of these shrimp species from the FWSI project area, or elsewhere in the County although suitable habitat for all three species is present. Approximately 8,500 acres of suitable habitat lies within existing urban limit lines and are designated for development in County or city general plans.

Soft Bird's-beak

The soft bird's-beak is present within the FWSI project area. One historical population near Martinez has been extirpated. Extant populations in the FWSI project area are known from the Concord Naval Weapons Station, Suisun Bay, and the edge of the Carquinez Strait northeast of Shore Acres. Two other populations are known outside the project area at Point Pinole Regional Shoreline. Approximately 500 acres out of a total of 4,000 acres of suitable habitat lies within existing urban limit lines and are designated for development in County or city general plans.

Regional Environmental Manager

60

Habitat quality for the population at Suisun Bay south of Middle Point is considered good. This population consisted of five groups totaling over 12,000 plants in 1992. Habitat quality for the population at the edge of the Carquinez Strait near Shore Acres is fair. The population has been declining as a result of disking and from excessive grazing by livestock, with very few individuals observed in recent years. The population at the Concord Naval Weapons Station consists of two sub-populations and the number of individuals has been increasing in recent years.

Contra Costa Goldfields

Suitable habitat for the goldfields is present within the FWSI project area. One occurrence of the goldfields was located in 1995 immediately adjacent to the FWSI project area near the headwaters of Rodeo Creek, just north of State Route 4. The population is currently protected (Betty Warne, USFWS, pers.comm.). Undocumented populations may still exist in the County.

A historical occurrence of goldfields near Byron Hot Springs, south of the FWSI project area, could not be relocated during surveys conducted in vernal pool habitat in the Kellogg Creek watershed (California Department of Fish and Game 1997). The only other historical occurrences of the species in the County, one near Concord and one in Walnut Creek, are presumed to have been extirpated by urban development (California Department of Fish and Game 1997).

Effects of the Action

Direct effects include those actions that are the direct result of the proposed action. Direct effects include interrelated actions (actions that are part of the larger proposed action and depend on the larger action for their justification) and interdependent actions (actions having no independent utility apart from the proposed action). Indirect effects are caused by or result from the proposed action, are later in time and are reasonably certain to occur. The proposed action is the construction of the MPP.

Construction and Operation of the Multipurpose Pipeline

The following species may be directly and indirectly affected by the construction of the MPP project: red-legged frog; longhorn fairy shrimp; fairy shrimp; tadpole shrimp; and Costa goldfields. All species may be directly effected from construction activities resulting from the construction and/or repair of the pipeline. These activities include, but are not limited to: trenching, stockpiling excavated material, operation of construction vehicles and other construction-related activities. These activities could result in the temporary removal of vegetation, temporary draining of wetland areas; disturbance of drainage channels, sedimentation, and direct mortality from equipment operation from the construction and maintenance of the MPP. All species may be effected from maintenance staff driving along the ROW twice yearly checking

Regional Environmental Manager

61

for leaks, particularly if they are required to drive off-road. No species will be directly or indirectly impacted by the RWP.

California red-legged frog

Potential red-legged frog habitat is present within drainages crossed by the MPP that support riparian vegetation. Potential habitat for red-legged frog occurs in nine drainages: 1, 2b, 4, 12, 13, 116b, 17a, 20a and 20b (Figs. 3a - 3c). Less than 0.1 acre of habitat will be disturbed at these drainages.

Wetlands C-W4 and C-W5 (Fig. 3b) may support red-legged frogs. These wetlands total less than 0.4 acre.

Red-legged frogs may be impacted by construction activities. Breeding behavior may be modified because of construction related noises. Eggs masses and/or tadpoles may be effected by sedimentation and/or debris resulting from construction activities. Removal of riparian vegetation will leave all life stages vulnerable to displacement and increased predation pressure.

Longhorn Fairy Shrimp, Vernal Pool Tadpole Shrimp, and Vernal Pool Fairy Shrimp

Seasonal wetlands C-W4, C-W5, and C-W6 (Fig. 3b) adjacent to the Contra Costa Canal access road provide potential habitat for these species. Although outside the project boundary, these pools could be affected by construction related sedimentation.

Suitable seasonal wetland habitats for these species are present in wetlands M-W3 through M-W8, M-W11, and M-W12 along the Mallard Pipeline ROW (Fig. 3a). Temporary impacts from pipeline trenching could affect up to 0.8 acre (wetland areas M-W3 through M-12 (Fig. 3a)). Construction of the maintenance road could result in the permanent loss of approximately 0.3 acres of shrimp habitat. Indirect effects could include the introduction of deleterious substances, such as construction-related runoff and debris, into vernal pool habitats along the MPP.

Deleterious substances from construction activities including introducing sediment and petroleum substances into vernal pool habitats could effect shrimp species.

Contra Costa goldfields

Maintenance road construction could result in the permanent loss of approximately 0.3 acre of potential goldfields habitat. Temporary direct impacts from pipeline trenching to potential habitat could affect up to 0.8 acre for seasonal wetland areas M-W3 through M-W8, M-W11 and

M-W12(Fig 3b). Indirect effects could include the introduction of deleterious substances, such as construction-related runoff and debris, into vernal pool habitats along the MPP.

Future Water Supply Implementation Project Area Habitats

The project area is located in north central and east County. It is bordered by Suisun Bay and the San Joaquin River on the north and the Delta on the northeast. CCWD has diversion facilities on Old River near Highway 4, at Rock Slough and at Mallard Slough. The project area encompasses approximately 120,657 acres (not including 19,500 acres of open-water habitat Bay-Delta channels), of which slightly more than half are developed (Fig. 4). Approximately two thirds of the undeveloped acres are designated for open space or agricultural uses on county and city general plans. The distribution of project area acreage by habitat type is shown on Table 6.

Table 6. Habitat types and acreage in the FWSI project area.

Habitat Type	Acres
Native Habitats	
Open water	1,226
Brackish marsh/mudflat	4,901
Freshwater marsh	1,442
Annual grassland	14,503
Seasonal wet grassland	7,975
Plowed seasonal wet grassland	6,863
Oak woodland	10,883
Shrubland/chaparral	2,814
Total	50,607
Agricultural Habitats	3,929

The delivery and application of CCWD water can adversely affect the reproduction, growth, survival, migration, predator avoidance, and foraging behavior of federally listed species in the action area. Activities that result directly from or are supported or facilitated by construction of the MPP include: (1)diversions, including continued operations of the facilities, (2) agricultural conversions and related operations, and (3) municipal and industrial development. These activities have and will continue to directly and indirectly affect listed species and their habitat within the action area. These activities are described in greater detail below.

Agricultural Conversions and Related Operations. Agricultural conversions and related operations facilitated by the CVP deliveries through the MPP that could impact listed species or their habitats include: conversion of native habitats to agricultural fields; conversion of land use to more water-intensive purposes; application of pesticides; and mowing and other harvesting operations.

Most of the listed species' habitat that has been converted using CVP water will be unusable by listed species. Land conversion due to agricultural operations is usually a permanent event that sets a new threshold for some feature of a species' environment, due to the permanent loss of habitat. At times, land is fallowed which may allow for listed species to become reestablished. Some agricultural lands may be usable by listed species depending on the intensity of the land management for agricultural development.

Municipal and Industrial Development. Municipal and industrial development facilitated by the CVP deliveries through the MPP could impact listed species or their habitats include actions such as the following: conversion of habitat to municipal and industrial uses; conversion of agricultural land for municipal and industrial uses; construction of infrastructure and supportive networks; pesticide and herbicide application; and recreational uses. Urban developments can cause increased erosion, increased roadkill of wildlife, increased pesticide use, reduced water and air quality, and increased disturbance such as noise.

The listed species' habitat that has been lost due to municipal and industrial development is expected to remain unusable by listed species. Land conversion due to municipal and industrial development is a permanent event that sets a new threshold for some feature of a species' environment, due to the permanent loss of habitat.

Municipal and industrial development in the County will be facilitated by the MPP by the direct delivery of CCWD water to the cities. Development could be facilitated on approximately 50,000 acres of various vegetation types within CCWD's service area. However, not all lands are at the same risk of being developed.

The direct effects of the action include diversion of water from the Delta and the delivery of that water to CCWD's service area. The remainder of the Contra Costa service area is also directly affected by the action, because water could be freed up for use in these areas immediately upon delivery of the new contract water to CCWD.

Delta Smelt and Sacramento Splittail

In-Delta Effects: Modeling of delivery of an additional 40 TAF of water from the Delta under the anticipated future CCWD demands has shown a potential effect on the position of X2, delta outflow, QWEST and flows in Old and Middle Rivers. These potential impacts are dependent upon CVP system wide water operations and allocations, and as such are indirectly related to CCWD's operations. For example, the CVPIA PEIS indicates that as demands on the CVP system grow, shortages increase, and therefore some or all of these potential effects will not be realized.

Diversion of an additional 40 TAF of water from the Delta under the proposed CCWD water contract has a demonstrated effect on the position of X2, delta outflow, QWEST, and flows in Old and Middle River. Moyle et al. (1992) have demonstrated that the decline of freshwater outflows

during the delta smelt rearing interval of February through July has matched the decline of populations of delta smelt over the past 20 years. Because delta smelt have a one-year life history, changes in habitat can rapidly lead to declining populations and extinction. Any decrease in inflow to the Sacramento-San Joaquin Delta during the critical rearing period results in decreased outflow that shifts the position of the mixing zone upstream to less suitable habitat caused by unfavorable salinity regimes and geographic dispersion, higher levels of contaminants, and higher losses to agricultural and municipal diversions, thus adversely affecting delta smelt and their critical habitat. The Sacramento splittail will be affected by the proposed water diversions similarly as the delta smelt.

In the BA for the CCWD FWSI, DWRSIM was used to model the effects on future water diversion from the Delta. Several model runs were completed for the BA (Anonymous, 1999), however, we analyzed the following parameters: the movement of X2, Delta outflow, QWEST, flows in Old and Middle River, and exports at the CVP and SWP. These parameters were modeled on a monthly basis for 72 water years (1922-1994) under two different sets of conditions: (1) existing conditions within CCWD at 148 TAF diversion rate; and (2) change in existing conditions with the future water supply project at 205 TAF. The change in X2 over the 72 year span is significant, with X2 moving upstream over 30% of the time from January through June. In May, the upstream movement of X2 occurs 54% of the time. The maximum movement of X2 is 1.6 km, but the average is between 0.2 to 0.5 km. Water year type was also provided. During dry, below normal, and critical dry years, X2 movement upstream occurred in significant numbers. This movement could adversely affect spawning and rearing habitat of delta smelt because the location of X2 has been significantly correlated with successful reproduction in delta smelt. For successful reproduction and recruitment, X2 needs to be located at Chipps Island, or farther east.

The second parameter measured was delta outflow. The data indicate that outflow decreased in every month analyzed, over 40% of the time. In January and May, delta outflow was decreased 80% of the time. The maximum that outflow was reduced was 1,981 cubic feet per second (cfs). During all categories for dry years, delta outflow was much lower with the future water supply. However, these were singular events, probably the result of non-linear calculations in the model rather than directly related to CCWD operations. Changes of this magnitude rarely occurred in the model studies and are an order of magnitude larger than CCWD's diversion rate.

The third parameter measured was QWEST. The modeling data for QWEST was only given on a 70 year time frame. QWEST became more negative (net upstream direction) over 90% of the time. In the months of April and May, QWEST became negative in 100% of the iterations. The maximum that QWEST was negative was 1,987 cfs. Again, these were singular events, probably the result of non-linear calculations in the model rather than directly related to CCWD operations. Changes of this magnitude rarely occurred in the model studies and are an order of magnitude larger than CCWD's diversion rate.

Flows in Old and Middle River were also analyzed. The flows moved upstream over 80% of the time. In May, the upstream effect occurred 96% of the time. The maximum upstream effect was 1,146 cfs. During dry years, Old and Middle River flows were negative a majority of the time.

The CVP and SWP did not show any significant change throughout the modeling iterations. This change could be explained due to the fact that a small amount of water diverted for CCWD does not effect the export facilities. Furthermore, the modeling assumed operational rules do not change with time; consequently the above-mentioned impacts are probably on the high side. The CVPIA PEIS indicates that in all but the wettest years, total CVP deliveries are limited; therefore, it is likely that many of the effects would be offset by changes in CVP allocations in most years. Such global effects would be addressed globally in consultations with Reclamation on the CVP OCAP or CVP contract renewals.

Reclamation maintains that CCWD's future water diversions would have no demonstrable or measurable effects on delta aquatic conditions (Anonymous, 1999). However, the data above indicate that measurable effects could occur in some water years. Although the upstream movement of X2, the decrease in Delta outflow, the negative QWEST, and the negative Old and Middle River flows caused by the CCWD future water diversions are clearly small compared to the effects of water exported by the Harvey O. Banks and Tracy Pumping Plant and other large diverters, any increment that decreases outflow must be considered an adverse effect to delta smelt.

CUMULATIVE EFFECTS

Cumulative effects include the effects of future State, Tribal, local, or private actions affecting listed species and their critical habitat that are reasonably certain to occur in the area considered in this biological opinion. Future Federal actions not related to this proposed action are not considered in determining the cumulative effects, but are subject to separate consultation requirements pursuant to section 7 of the Act.

An undetermined number of future land use conversion, routine agricultural practices and fire control practices are not subject to Federal permitting processes and may alter the habitat or increase incidental take of kit fox, red-legged frogs, longhorn fairy shrimp, vernal pool tadpole shrimp, vernal pool fairy shrimp, delta smelt, splittail, Alameda whipsnake, and California least tern, and are, therefore, cumulative to the proposed project. These additional cumulative effects include: (1) unpredictable fluctuations in aquatic habitat due to water management; (2) dredging and clearing vegetation from irrigation canals and stock ponds; (3) underground culverts in creeks for flood control; (4) disking or mowing upland habitat; (5) development of golf courses, and (6) an undetermined number of future land use conversions and routine agricultural practices.

San Joaquin kit fox. Increased residential/industrial project may remove kit fox foraging and denning habitat, further educing its range. Increases in the human population will increase

recreational uses in the LV Reservoir area and local regional parks. Black Diamond Mines regional Park and control Loma regional Park support kit foxes. Increase visitations to these open space areas may impact kit fox by interfering with normal behavioral patterns. Recreational demands will also increase the demand for golf courses within the area. The Roddy Ranch golf course currently under construction involves conversion of kit fox habitat.

Delta Smelt and Sacramento Splittail. Cumulative effects on the delta smelt, splittail, or delta smelt designated critical habitat include any continuing or future non-Federal diversions of water that may entrain adult or larval fish or that may decrease outflows incrementally, thus shifting the position of the delta smelt's preferred habitat upstream. Water diversions through intakes serving numerous small, private agricultural lands and duck clubs in the Delta, upstream of the Delta, and in Suisun Bay contribute to these cumulative effects. These diversions also include municipal and industrial uses, as well as providing water for power plants.

Additional cumulative effects result from the impacts of point and non-point source chemical contaminant discharges. These contaminants include selenium and numerous pesticides and herbicides associated with discharges related to agricultural and urban activities. Implicated as potential sources of mortality for delta smelt and splittail, these contaminants may adversely affect delta smelt and splittail reproductive success and survival rates. Spawning habitat may also be affected if submersed aquatic plants used as substrates for adhesive egg attachment are lost due to toxic substances. State or local levee maintenance may also destroy or adversely modify critical habitat by disturbing spawning or rearing habitat and resuspending contaminants into the water.

The introduction of exotic species may occur when levees are breached or when separate creeks or river systems are reconnected during various projects. Several exotic species may adversely affect the delta smelt and splittail, including the Asian clam (*Potamocorbula amurensis*) and three non-native species of euryhaline copepods. The Asian clam could potentially play an important role in affecting the phytoplankton dynamics. The exotic copepods may displace native species and at least one species of copepods (*Sinocalanus doerri*) is difficult for larval fishes to catch because of its fast swimming and effective escape response. Reduced feeding efficiency and ingestion rates weaken and slow the growth of young and make them more vulnerable to starvation and predation.

Other cumulative effects include: wave action in water channels caused by boats may degrade riparian and wetland habitat and erode banks; the dumping of domestic and industrial garbage may present hazards to the fish because they could become trapped in the debris, injure themselves, or ingest the debris; golf courses may reduce habitat and introduce pesticides and herbicides into the environment; oil and gas development and production remove habitat and may introduce pollutants into the delta; agricultural uses on levees may reduce riparian and wetland habitats; residential or agricultural land use can fragment and reduce wildlife habitat and corridors; unscreened agricultural diversions throughout the delta divert all life stages of the fish (Service 1995); and grazing activities may degrade or reduce suitable habitat.

Salt Marsh Harvest Mouse and Clapper Rail. Small projects, such as the Wickland Copart Auto Dismantling, are being proposed along the upland edge of salt marshes. Although these proposed project may not be directly impacting salt marsh, they may preclude upland use of grasslands as refugia during high tides. They may introduce nighttime lighting thereby encouraging predators into the area creating additional predatory pressures on the salt marsh harvest mouse. In addition, industrial/urban development provide habitat for house mouse (*Mus musculus*) and rats (*Rattus norvegicus*), which may compete with harvest mice for resources.

A number of factors influencing the remaining tidal marshes limit their habitat value, including freshwater influxes and direct loss of habitat. Intertidal and riparian marsh habitats used by species such as the California clapper rail and salt marsh harvest mouse may be degraded or destroyed by a variety of development and maintenance activities conducted by private organizations or state or local governments. Increased urban development has also increased problems associated with non-native predators, freshwater urban run-off, and disturbance of breeding and foraging behavior.

California Red-Legged Frog. Oak woodlands are increasingly under pressure from development of housing and recreation facilities (such as golf courses). Urban and agricultural development, rangeland improvement, and other activities continue to eliminate oak woodland habitats. Introduced bullfrogs pose a great threat to California red-legged frogs. Adult bullfrogs are accomplished predators which can populate an area quickly and out-compete the natives. Bullfrog proliferation is encouraged by developments that have permanent standing water sources (such as golf courses and ornamental ponds). Eggs and larvae of California red-legged frogs can be killed or injured by mosquito abatement activities.

Increased vehicular traffic is an ongoing hazard that can cause roadkill mortality. Traffic will be increased by construction of new roads and agricultural, industrial, and urban development. As barriers to dispersal, roads also reduce the probability that unoccupied habitat will be colonized by listed species.

Furthermore, the increased runoff and nuisance flows from development and will result in an increase in base summer flows in the streams below the project areas, converting them from intermittent to perennial water courses. This change in hydrology will allow exotic species such as bullfrogs to advance higher up into the watershed and colonize California red-legged frog habitat. In addition to the colonization by bullfrogs, other urban adapted predators such as raccoons, skunks, opossums, rats, and pets will increase. This increase in predators will reduce the overall numbers of the subpopulation.

Giant Garter Snake. Cumulative effects that may affect giant garter snakes throughout their range include: (1) unpredictable fluctuations in aquatic habitat due to water management; (2) dredging and clearing vegetation from irrigation canals; (3) discing, mowing, ornamental cultivation, and routine grounds maintenance of upland habitat; (4) increased vehicular traffic on access roads adjacent to aquatic habitat; (5) use of burrow fumigants on levees and other potential upland refugia; (6) contaminated runoff from agriculture and urbanization; and (7) predation by feral

animals and pets. Introduced bullfrogs pose a threat to young giant garter snakes. Adult bullfrogs are accomplished predators which can populate an area quickly and outcompeted the natives.

Vernal Pool Species. A wide range of activities will affect vernal pool species in Solano County. Such activities include, but are not limited to, urban, water, flood control, highway and utility projects, chemical contaminants, as well as conversion of vernal pools to agricultural use. An undetermined number of future unauthorized and unpermitted projects that alter the habitat of the vernal pool tadpole shrimp, vernal pool fairy shrimp, longhorn fairy shrimp, Contra Costa goldfields are expected to occur.

Activities that can contribute to vernal pool habitat losses include plowing and deep-ripping for agriculture, urban development, flood control projects, highway and utility projects, and overgrazing. Limited distributional patterns increase the susceptibility of individual populations and entire species to severe declines from both natural and human-induced disturbances. Much of the remaining vernal pool habitat has been degraded by fragmentation, changes in hydrology, off-road vehicle use, increased competition from non-native species, and miscellaneous human disturbances. In many areas, the cumulative effects of habitat loss, fragmentation, and degradation have reduced the potential for remaining habitats to indefinitely sustain viable populations of rare species. Few of the remaining vernal pools are permanently protected. The greatest loss of vernal pools comes from the conversion to agricultural purposes. Vernal pool species may be injured or killed by mosquito abatement measures including pesticide application and predation by introduced mosquitofish.

Alameda whipsnake. As urban development encroaches into undeveloped areas, particularly where chapparel abuts urban development, vegetation management for fire suppression may impact whipsnakes through vegetation removal and discing of firebreaks.

California least terns. Least terns may be effected at their nesting sites by increases in urban development that may occur in the project area. Increased numbers people often cause an increase in the urban adapted native and non-native predators which may eat eggs and prey on chicks.

Contra Costa Goldfields and Soft Bird's-Beak. In San Pablo and Suisun Bays the average salinity has increased due to upstream diversions of water projects. Intertidal and riparian marsh habitats used by species such as the soft bird's-beak may be degraded or destroyed by a variety of development and maintenance activities conducted by private organizations or state or local governments.

Introduced plants have caused problems for native species. Non-native plants compete with native plants for light, space, and nutrients. The lack of natural population controls for non-natives (i.e., predators, disease, etc.) can allow these species to completely outcompeted native species and form a monoculture of an introduced species. Species such as the yellow star thistle (*Centaurea solstitialis*), barb goatgrass (*Aegilops triuncialis*), and medusahead (*Taeniatherum caput-*

medusae) have out-competed native species in California. Listed plants are lost due to authorized and unauthorized conversion of native habitat for agricultural and urban development. Listed plants may also be threatened by vandalism or horticultural collecting. Listed plant species endemic to vernal pool habitats are adapted to hydroperiods with winter inundation and summer drying, and are outcompeted by marsh plants when standing water is permanently present.

Most native plant species have adapted to a certain level of grazing pressure. Grazing management practices may be incompatible with the continued survival of certain species. For many species, the grazing management which would best suit the species is simply unknown. This may lead to inappropriate habitat management practices.

Management regimes that pose a threat to listed plant species include: lack of protection on private lands, lack of funding for protection, lack of funding for correct management, management practices for one species that eliminates another, or inappropriate habitat management due to lack of information on the biology of the species. Private land management practices can also be incompatible with the continued viability of species.

Conclusion

After reviewing the current status of the harvest mouse, clapper rail, delta smelt, splittail, red-legged frog, kit fox, giant garter snake, whipsnake, least tern, longhorn fairy shrimp, fairy shrimp, tadpole shrimp, goldfields, and soft bird's-beak, the environmental baseline, and the cumulative effects, it is the Service's biological opinion that the proposed action is not likely to jeopardize the continued existence of these species, or result in the destruction or adverse modification of critical habitat for delta smelt. This conclusion holds true only if CCWD's Conservation Measures outlined in this biological opinion are implemented.

INCIDENTAL TAKE STATEMENT

Section 9 of the Act and Federal regulation pursuant to section 4(d) of the Act prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harass is defined by the Service as an intentional or negligent act or omission which creates the likelihood of injury to a listed species by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering. Harm is defined by the Service to include significant habitat modification or degradation that results in death or injury to listed species by impairing behavioral patterns including breeding, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the Act provided that such taking is in compliance with this Incidental Take Statement.

Sections 7(b)(4) and 7(o)(2) of the Act do not apply to the incidental take of listed plant species. However, protection of listed plants is provided to the extent that the Act requires a Federal permit for removal or reduction to possession of endangered plants from areas under Federal jurisdiction, or for any act that would remove, cut, dig up, or damage or destroy any such species on any other area in knowing violation of any regulation of any State or in the course of any violation of a State criminal trespass law.

The measures described below are non-discretionary, and must be implemented by the Reclamation so that they become binding conditions of any grant or permit issued to the applicant, as appropriate, in order for the exemption in section 7(o)(2) to apply. Reclamation has a continuing duty to regulate the activity covered by this incidental take statement. If Reclamation (1) fails to require the applicant to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the permit or grant document, and/or (2) fails to retain oversight to ensure compliance with these terms and conditions, the protective coverage of section 7(o)(2) may lapse.

The amount of incidental take addressed below is for those actions that are within Federal discretion for the purposes of section 7 of the Act. As discussed in the Effects of the Proposed Action, the anticipated take from the proposed action transcends Federal discretion due to the indirect effects of the proposed action due to the use or application of Federal water for . As discussed in the CCWD's Conservation Measures, CCWD has agreed to participate in the development of an HCP for their service area effect and receive incidental take authorization by obtaining a 10(a)1(B) permit for otherwise lawful activities that are beyond Federal discretion. Furthermore, CCWD will limit water delivery to 148 TAF until a 10(a)1(B) permit is issued by the Service. Those actions which are covered by this incidental take statement, and those which will require future incidental take authorization are discussed in more detail below.

Amount or Extent of Take

Implementation of CCWD's Conservation Measures will substantially reduce, but not eliminate, the potential for incidental take of listed species resulting from construction and maintenance of the MPP. The actions and processes for which this incidental take statement applies include the direct effects of construction and maintenance for the MPP for impacts to vernal pool fairy shrimp, vernal pool takpole shrimp, longhorn fairy shrimp, and California red-legged frog. The actions of individual entities in utilizing CCWD water for either agricultural, municipal and industrial purposes are not exempt for section 9 prohibitions and are not covered by this incidental take statement. This biological opinion does not authorize incidental take for giant garter snake, San Joaquin kit fox, Alameda whipsnake, California clapper rail, California least tern, and salt marsh harvest mouse.

Activities Covered by This Incidental Take Statement - Incidental take of listed species may result from the construction and normal operation and maintenance of MPP facilities the protection measures established under CCWD's Conservation Measures. These activities may include:

routine maintenance of the MPP, mowing; grading and repair of roads; spraying, drift, and/or runoff of herbicide or insecticide on the facilities. These activities may also include ordinary operations and maintenance activities similar in scope, impact, and duration to those above but not specifically listed.

Activities Not Covered by This Incidental Take Statement - Incidental take of listed species caused by the following activities is not authorized by this incidental take statement: construction of new water delivery or treatment facilities; construction of private development projects served by CCWD water; the indirect effects (*i.e.*, conversion of listed species habitat to urban development) of delivery of the water; maintenance activities on privately owned water delivery systems; and other private actions related to the use of CCWD water. Projects that would require Corps permits for fill of wetlands under Section 404 of the Clean Water Act will require separate section 7 consultation (programmatic or site-specific), and incidental take for such projects is not authorized under this opinion. Incidental take for those projects without a Federal nexus will be addressed in the HCP for CCWD contract service area, as discussed in CCWD's Conservation Measures of this biological opinion.

Vernal Pool Crustaceans - The Service expects that incidental take of the vernal pool crustaceans (vernal pool fairy shrimp, vernal pool tadpole shrimp, and longhorn fairy shrimp) will be difficult to quantify for the following reasons: (1) the aquatic nature of the organisms and their relatively small body size make the finding of dead or injured specimens unlikely, (2) the variable sizes of resident populations over time, and (3) the difficulty of detecting and tracking all operations and maintenance activities that may result in harassment of listed species. Due to the difficulty in quantifying the number of vernal pool crustaceans that will be taken as a result of the proposed action, the Service is quantifying take incidental due to the proposed project as the number of acres of habitat that will become unsuitable for the species as a result of the action. Therefore, the Service has determined that the construction of the MPP and continued operations and maintenance of the MPP could result in the loss of all vernal pool crustaceans inhabiting as much as, but no more than 1.1 acres of vernal pool crustacean habitat. This incidental take estimation does not extend to any activity that results in fill of water of the United States under the jurisdiction of the Corps, beyond 1.1 acres identified above.

California red-legged frog. The Service expect that incidental take of red-legged frogs will be difficult to quantify for the following reasons: (1) the aquatic nature of the organisms and their relatively small body size make the finding of dead or injured specimens unlikely, (2) the variable sizes of resident populations over time, and (3) the difficulty of detecting and tracking all operations and maintenance activities that may result in harassment of listed species. Due to the difficulty in quantifying the number of red-legged frogs that will be taken as a result of the proposed action, the Service is quantifying take incidental due to the proposed project as the number of acres of habitat that will become unsuitable for the species as a result of the action. Therefore, the Service has determined that the construction of the MPP and continued operations and maintenance of the MPP could result in the loss of all red-legged frogs, eggs and tadpoles inhabiting as much as, but no more than 0.5 acre of red-legged frog habitat. This incidental take

Regional Environmental Manager

72

estimation does not extend to any activity that results in fill of water of the United States under the jurisdiction of the Corps, beyond the 0.5 acre identified above.

In summary, upon implementation of the following reasonable and prudent measures, incidental take associated with construction, operations and maintenance of the MPP on 1.1 acres of vernal pools and 0.5 acre of red-legged frog habitat will become exempt from the prohibitions described under section 9 of the Act for direct impacts due to the construction, operations and maintenance of the MPP. Vernal pool crustaceans and red-legged frogs in the quantities described above, may be harmed, harassed, injured, or killed in association with the proposed project. No other forms of take are expected to occur, therefore this exemption does not extend to other forms of take.

Delta Smelt and Sacramento Splittail

The level of take for delta smelt and Sacramento splittail is difficult to quantify in terms of numbers of individuals because of the variation in population size and distribution within the volume of diverted water. For this reason, the Service estimates the level of take in terms of total volume of water diverted annually.

Incidental take of delta smelt and Sacramento splittail may occur through the year as a result of diversion of a total of 148 TAF. This incidental take has already been covered by the LVP. Incidental take of the delta smelt and Sacramento splittail habitat in the form of downstream flow reductions, water quality impairment, or changes in the Delta environment is not exempt from section 9 prohibitions authorized in this biological opinion beyond the incidental take already through existing biological opinion on the LVP. CCWD will limit water delivery to 148 TAF until a 10(a)1(B) permit is issued by the Service, as described in CCWD's Conservation Measures. Reclamation will initiate consultation on the contract renewals and reinitiate on the CVP OCAP. If neither consultation by Reclamation on the contract renewals required under the CVPIA nor a re-analysis of the CVP OCAP opinion are complete, and/or the Service determines that the then current biological opinions do not sufficiently address global issues related to CVP operations, the appropriate biological opinion(s) may be reinitiated to analyze any changed circumstances at that time. If the OCAP consultation or contract renewal consultation provides for incidental take authority of a lesser amount, then there will be reinitiation of consultation for the increment."

Upon implementation of the following reasonable and prudent measures, the volumes of diverted delivery water described above will become exempt from the prohibitions described under section 9 of the Act for the proposed project. Delta smelt and Sacramento splittail may be harmed, harassed, injured, or killed by direct entrainment in association with the proposed project within the volume of water exempted under section 9 of the Act. No other forms of take are authorized under this opinion.

Effect of the Take

The Service has determined that this level of anticipated take is not likely to result in jeopardy to salt marsh harvest mouse, California clapper rail, delta smelt, Sacramento splittail, California red-legged frog, giant garter snake, longhorn fairy shrimp, vernal pool fairy shrimp, and vernal pool tadpole shrimp, Contra Costa goldfields, and soft bird's-beak, or destruction or adverse modification of critical habitat of delta smelt. Salt marsh harvest mouse, California clapper rail, Sacramento splittail, California red-legged frog, giant garter snake, longhorn fairy shrimp, vernal pool fairy shrimp, and vernal pool tadpole shrimp, Contra Costa goldfields, and soft bird's-beak do not have designated critical habitat, so no critical habitat for these species will be destroyed or modified.

Reasonable and Prudent Measures

The following reasonable and prudent measures are necessary and appropriate to minimize the impacts of the CCWD's construction and maintenance of the MPP and delivery of said water on red-legged frogs, vernal pool crustaceans, delta smelt and Sacramento splittail.

1. Harrassment, harm and mortality of California red-legged frogs during construction and operations associated with implementing the project shall be minimized.
2. Harrassment, harm and mortality of vernal pool crustaceans during construction and operations associated with implementing the project shall be minimized.
3. Avoid adverse effects on instream flow and Delta water conditions for delta smelt and Sacramento splittail.

In order to be exempt from the prohibitions of section 9 of the Act, Reclamation must ensure compliance with the following terms and conditions, which implement the reasonable and prudent measures described above. These terms and conditions are non-discretionary.

1. The following terms and conditions implement reasonable and prudent measure numbers 1 and 2:
 - A. Reclamation shall ensure that all CCWD's Conservation Measures described on pages 21 through 26 of this biological opinion are adhered to.
 - B. Reclamation shall ensure that projects with pending or future inclusions requests for CVP water will be approved only if the applicant 1) has completed a section 7 consultation with either Reclamation or other Federal agency; 2) has obtained a section 10(a)(1)(B) permit from the Service; or 2) falls within the jurisdiction of a regional HCP, prior to obtaining CVP water.
 - C. All individuals handling listed species shall hold a valid 10(a)(1)(A) Recovery Permit from the Service. Alternatively, the Service may authorize additional

individuals in writing to handle listed species specifically for this project, if said individuals provide proof of experience for specific listed species. Approval of said individuals will be entirely at the discretion of the Service.

- D. Prior to beginning construction in wetlands, Reclamation shall submit specifications for fencing to be construction for the protection of listed species for review and approval by the Service.
 - E. Submit a list a plants for riparian planting for review and approval by the Service.
 - F. Staging areas adjacent to listed species habitat shall be inspected, approved, and clearly delineated by an approved biologist.
 - G. Replacement of vernal pool habitat and other seasonal wetlands shall be approved by the Service.
 - H. Reclamation shall not allocate the additional 40 TAF until the east county HCP is completed and the Section 10(a)(1)(B) permit(s) is(are) issued.
2. The following terms and conditions implement reasonable and prudent measure number 3:
- A. Reclamation shall determine delivery amounts for CCWD water contracts in a manner consistent with any future programmatic biological opinions covering CVP water deliveries.
 - B. Without the prior approval of Reclamation and completed consultation with the Service under section 7 of the Act, CCWD'S CVP water or other water that may require Reclamation review and approval, may be sold, transferred or exchanged outside CCWD's contract service area. This is to ensure that no water transfer of Federal water results in the loss or degradation of listed species or their habitat.

Reporting Requirements

Reclamation shall require personnel to report immediately any information about take or suspected take of listed species. Reclamation shall immediately notify the Service within one working day of any such information. Notification must include the date, time, and precise location of the incident/specimen, and any other pertinent information. For non-fish species Reclamation shall submit locality information to the Service and Department, using completed California Native Species Field Survey Forms or their equivalent, no more than 90 calendar days after completing the last field visit of the project site. Each form shall have an accompanying scale map of the site such as a photocopy of a portion of the appropriate 7.5 minute U.S. Geological Survey map and shall provide at least the following information: township, range, and quarter section; name of the

Regional Environmental Manager

75

7.5' or 15' quadrangle; dates (day, month, year) of field work; number of individuals and life stage (where appropriate) encountered; and a description of the habitat by community-vegetation type. The Service contact shall be the Division Chief, Endangered Species Division at (916) 414-6620. Any killed fish specimens that have been taken shall be properly preserved in accordance with Natural History Museum of Los Angeles County policy of accessioning (10% formalin in quart jar or freezing). Information concerning how the fish was taken, length of the interval between death and preservation, the water temperature and outflow/tide conditions, and any other relevant information shall be written on 100% rag content paper with permanent ink and included in the container with the specimen. Preserved specimens shall be delivered to the Service's Division of Law Enforcement at 2800 Cottage Way, Room W-2928, Sacramento, California 95825-1846, phone (916) 414-6660.

CONSERVATION RECOMMENDATIONS

Sections 2 (c) and 7(a)(1) of the Act direct Federal agencies to use their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and threatened species and the ecosystems upon which they depend. Conservation recommendations are Service suggestions regarding discretionary agency activities to promote the recovery of listed species. Therefore, the Service recommends the following additional actions to promote the recovery of federally listed species and their habitats:

1. Reclamation should assist in the implementation of the recovery plans for the species discussed in this biological opinion.
2. Reclamation should conduct adequate baseline monitoring to determine and analyze service area effects.

In order for the Service to be kept informed of actions that either minimize or avoid adverse effects or that benefit listed species or their habitats, the Service requests notification of the implementation of any conservation recommendations.

REINITIATION - CLOSING STATEMENT

This concludes formal consultation on the proposed MPP and FWSI project. As provided in 50 CFR 402.16, re-initiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been maintained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the proposed action may affect listed species or critical habitat in a manner or to an extent not considered in this opinion; (3) the agency action is subsequently modified in a manner that causes an effect to listed species or critical habitat that was not considered in this opinion; or

Regional Environmental Manager

76

(4) a new species or critical habitat is designated that may be affected by the proposed action. In instances where the amount or extent of incidental take is exceeded, any operations causing such take must cease pending re-initiation.

If you have any questions regarding this biological opinion, please contact Sheila Larsen, Stephanie Brady or Ken Sanchez of my staff at (916) 414-6625.

Literature Cited

- Ahl, J.S.B. 1991. Factors affecting contributions of the tadpole shrimp, *Lepidurus packardii*, to its oversummering egg reserves. *Hydrobiologia* 212:137-1 Mr. Champ 43.
- Albertson, J.D. 1995. Ecology of the California Clapper Rail in South San Francisco Bay. M.A. Thesis, San Francisco State University.
- Anonymous, 1999.
- Arthur, J.F. and M.D. Ball 1980. The significance of the entrapment zone location to the phytoplankton standing crop in the San Francisco Bay-Delta Estuary. U.S. Dept. Interior, Water and Power Resources Service.
- Arthur, J.F. and M.D. Ball 1979. Factors influencing the entrapment of suspended material in the San Francisco Bay-Delta Estuary. Pages 143-174 in T.J. Conomos, editor. Pacific Division, Amer. Assoc. Advance. Sci., San Francisco, California.
- Arthur, J.F. and M.D. Ball 1978. Entrapment of suspended materials in the San Francisco Bay-Delta Estuary. U.S. Dept. Interior, Bureau of Reclamation, Sacramento, California.
- Atwood, J.L. and D.E. Minsky. 1983. Least tern foraging ecology at three major California breeding colonies. *Western Birds* 14:57-72.
- Bailey, S.F. 1984. California least tern foraging and other off-colony activities around Alameda Naval Air Station during 1984. Unpubl. report to U.S. Navy, Natural Resources Branch, San Bruno CA.
- Barclay, W.R. and A.W. Knight. 1984. Physio-chemical processes affecting production in a turbid vernal pool. Pages 126-142. IN S. Jain and P. Moyle, eds. Vernal pools and intermittent streams. Inst. Ecol. Pub. 28. Univ. Calif. Davis, California.
- Baxter R., 1994. August 1994 gill net survey to determine distribution, relative abundance, and proximity to shore of splittail in the Sacramento-San Joaquin Estuary. Annual Report of the Interagency Ecological Program, Resident Fishes Project Workteam. 6 pp
- Brett, J.R. 1976. Scope for metabolism and growth of sockeye salmon, *Oncorhynchus nerka*, and some related energetics. *J. Fish. Res. Bd. Can.* 33:307-313.
- Brode, J. 1988. Natural history of the giant garter snake (*Thamnophis couchii gigas*). In Proceedings of the conference on California herpetology, H.F. DeLisle, P.R. Brown, B. Kaufman, and B.M. McGurty (editors., p. 25-28. Southwestern Herpetologists Society, Special Publ. No. 4.

- California Department of Water Resources. 1992. Data and computations used to determine 1993 water charges. Bulletin 132-92, Appendix B. California Department of Water Resources, Sacramento, California. 136 pp.
- California Department of Water Resources and U.S. Bureau of Reclamation, Mid-Pacific Region 1993. Effects of the Central Valley Project and State Water Project on delta smelt. 134 pp.
- California Department of Water Resources and U.S. Bureau of Reclamation, Mid-Pacific Region 1994. Effects of the Central Valley Project and State Water Project on delta smelt and Sacramento splittail. 230 pp.
- CNDDDB. 1997. Natural Heritage Division. An electronic database application. California Department of Fish and Game. State of California.
- CNPS (California Native Plant Society). 1978. Rare Status Species Report, *Lasthenia conjugens*. An unpublished report. 3 pp.
- Coe, T. 1988. The application of section 404 of the Clean Water Act to vernal pools. Pages 356-358 in J. A. Kusler, S. Daly, and G. Brooks, eds. Urban wetlands. Proceedings of the National Wetland Symposium, Oakland, California.
- Collins, C.T., K.E. Bender and D.D. Rypka. 1979. Report on the feeding and nesting habits of the California least tern in the Santa Ana River marsh area, Orange County, California. Unpubl. report to U.S. Army Corps of Eng., Los Angeles, CA.
- Caywood, M.L. 1974. Contributions to the Life History of the Splittail *Pogonichthys macrolepidotus* (Ayres). M.S. Thesis, California State U., Sacramento. 77 pp.
- Dains, V. 1995. A study of Contra Costa goldfields (*Lasthenia conjugens*) at Potrero Hills and other locations in Solano County. Unpublished report, prepared for Global Environmental, Sacramento, CA. June 2, 1995. 12 pp. + appendix
- Dedrick, K.G. 1989. San Francisco Bay marshland tidal acreages: recent and historic values. In: Magoon, O.T. et al. (eds). Proceedings on the Sixth Symposium on Coastal and Ocean Management. Omni Hotel. Charleston, South Carolina, July 11-14, 1989. Volume 1, 383 pp.
- DeGroot, D.S. 1927. The California clapper rail: its nesting habits, enemies and habitat. Condor 29(6): 259-270.

- Daniels, R.A. and P.B. Moyle 1983. Life history of splittail (Cyprinidae: *Pogonichthys macrolepidotus*) in the Sacramento-San Joaquin Estuary. Fishery Bulletin 84-3:647-654.
- Donald, D.B. 1983. Erratic occurrence of anostracans in a temporary pond: colonization and extinction or adaptation to variations in annual weather? Can. J. Zool. 61:1492-1498.
- Driver, E.A. 1981. Caloric value of pond invertebrates eaten by ducks. Freshwater Biology 11:579-581.
- Eddleman, W.R., and C.J. Conway. 1994. Clapper rail. In T.C. Tacha and C.E. Braun (ed.): Migratory Shore and Upland Game Bird Management in North America. Allen Press, Lawrence, Kansas. 223 pp.
- Eng, L. L., D. Belk, and C. H. Erickson. 1990. California anostraca: distribution, habitat, and status. J. Crus. Biol. 10:247-277.
- Evens, J., and G. Page. 1983. The ecology of rail populations at Corte Madera Ecological Reserve: with recommendations for management. A report to Marin Audubon Society from Point Reyes Bird Observatory. 62 pp.
- Fitch, H.S. 1941. Geographic variation in garter snakes of the genus *Thamnophis sirtalis* in the Pacific coast region of North America. American Midland Naturalist, 26:570-592.
- Foe, Christopher. 1995. Evaluation of the potential impact of contaminants on aquatic resources in the Central Valley and Sacramento-San Joaquin Delta Estuary. Central Valley Regional Water Quality Control Board, Memorandum 60, June, 1995.
- Foerster, K.S., and J.E. Takekawa. 1991. San Francisco Bay National Wildlife Refuge Predator Management Plan and Final Environmental Assessment. Unpublished report.
- Foerster, K.S., J.E. Takekawa, and J.D. Albertson. 1990. Breeding density, nesting habitat, and predators of the California clapper rail. Final report SFBNWR-11640-90-1, prepared for San Francisco Bay National Wildlife Refuge. Newark, CA.
- Fugate, M. L. 1992. Speciation in the fairy shrimp genus *Branchinecta* (Crustacea: Anostraca) from North America. Ph.D. dissertation. Department of Biology, University of California, Riverside, California.
- Ganssle, D. 1966. Fishes and decapods of San Pablo and Suisun bays. Pp.64-94 in D.W. Kelley, ed.: Ecological studies of the Sacramento-San Joaquin Estuary, Part 1. Calif. Dept. Fish and Game, Fish Bulletin No. 133.

- Gilpin, M. E. and M. E. Soule. 1986. Minimum viable populations: processes of species extinction. Pages 19-34 in M. E. Soule, ed. Conservation biology: the science of scarcity and diversity. Sinauer Associates, Inc., Sunderland, Massachusetts.
- Goodman, D. 1987a. The demography of chance extinction. Pages 11-34 in M. E. Soule, ed. Viable populations for conservation. Cambridge University Press, Cambridge, Great Britain.
- Goodman, D. 1987b. How do any species persist? Lessons for conservation biology. Conservation Biology 1:59-62.
- Hansen, R. W. 1980. Western aquatic garter snakes in central California: an ecological and evolutionary perspective. Master of Arts thesis, California State University, Fresno, California, 78 pp.
- Hansen, G.E. 1988. Review of the status of the giant garter snake (*Thamnophis couchii gigas*) and its supporting habitat during 1986-87. Final report to California Department of Fish and Game, Contract C-2060. 31 pp.
- Hansen, G. E. and J. M. Brode. 1980. Status of the giant garter snake *Thamnophis couchii gigas* (Fitch). California Department of Fish and Game, Inland Fisheries Endangered Species Program Special Publication 80-5, 14 pp.
- Holland, R. F. 1978. The geographic and edaphic distribution of vernal pools in the Great Central Valley, California. California Native Plant Society, Special Publication 4:1-12.
- Holland, R. F., and S.K. Jain. 1988. Vernal pools. Pages 515-533 in M. E. Barbour and J. Major, eds. Terrestrial vegetation of California, new expanded edition. California Native Plant Society, Special Publication Number 9, Sacramento, California.
- Krapu, G.L. 1974. Foods of breeding pintails in North Dakota. J. Wild. Manag. 38(3):408-417.
- Hansen, R. W. and G. E. Hansen. 1990. *Thamnophis gigas* (giant garter snake) reproduction. Herpetological Review, 21(4): 93-94.
- Harvey, T.E. 1988. Breeding biology of the California clapper rail in south San Francisco Bay. 1988 Transactions of the Western Section of the Wildlife Society. 24:98-104.
- Hayes, M.P. and M.R. Jennings. 1988. Habitat correlates of distribution of the California red-legged frog (*Rana aurora draytonii*) and the foothill yellow-legged frog (*Rana boylei*): Implications for management. Pages 144-158 In: R. Szaro, K. E. Severson, and D. R. Patton (technical coordinators). Proceedings of the Symposium on the Management of Amphibians, Reptiles, and Small Mammals in North America. U.S.D.A. Forest Service

General Technical Report RM-166.

- Hayes, M.P. and M.M. Miyamoto. 1984. Biochemical, behavioral and body size differences between *Rana aurora aurora* and *R. a. draytonii*. *Copeia* 1984(4):1018-1022.
- Hayes, M.P. and M.R. Tennant. 1985. Diet and feeding behavior of the California red-legged frog, *Rana aurora draytonii* (Ranidae). *The Southwestern Naturalist* 30(4):601-605.
- Hopkirk, J.D. 1973. Endemism in the fishes of the Clear Lake region of central California. Univ. Calif. Publ. Zool. 96.
- Jennings, M.R. 1988. Natural history and decline of native ranids in California. Pages 61-72 In: H.F. DeLisle, P.R. Brown, B. Kaufman, and B.M. McGurty (editors). *Proceedings of the conference on California herpetology*. Southwestern Herpetologists Society, Special Publication (4):1-143.
- Jennings, M.R. and M.P. Hayes. 1985. Pre-1900 overharvest of California red-legged frogs (*Rana aurora draytonii*): The inducement for bullfrog (*Rana catesbeiana*) introduction. *Herpetologica* 41(1):94-103.
- Jennings, M.R. and M.P. Hayes. 1990. Status of the California red-legged frog *Rana aurora draytonii* in the Pescadero Marsh Natural Preserve. Report prepared for the California Department of Parks and Recreation, Sacramento, CA. 30 pp. + Tables and Figures.
- Jennings, M.R., M.P. Hayes, and D.C. Holland. 1992. A petition to the U.S. Fish and Wildlife Service to place the California red-legged frog (*Rana aurora draytonii*) and the western pond turtle (*Clemmys marmorata*) on the list of endangered and threatened wildlife and plants. 21 pp.
- Jones and Stokes Assoc., Inc. 1993. Sutter Bypass fisheries technical memorandum II: Potential entrapment of juvenile chinook salmon in the proposed gravel mining pond. May 27, 1993. (JSA 91-272). Sacramento, California. Prepared for Teichert Aggregates, Sacramento, California. 31 pp + Appendix.
- Jones and Stokes, Assoc. Inc. 1996. Amendment to the 1992 biological assessment for the California red-legged frog and the Alameda whipsnake for the Los Vaqueros Project. May. Sacramento, CA. Prepared for the U.S. Department of Interior, Bureau of Reclamation, Mid-Pacific region, Sacramento, CA and Contra Costa Water District, Concord, CA.
- Lanaway, C.S. 1974. Environmental factors affecting crustacean hatching in five temporary ponds. M.S. thesis. Department of Biological Science, Chico State University, Chico, California.

- Linder, F. 1952. The morphology and taxonomy of the branchiopod Nostraca, with special reference to the North American species. Proc. U.S. Nat. Mus. 102:1-57
- Longhurst, A.R. 1955. A review of the Nostraca. Bull. Brit. Mus. (Nat. Hist.) Zool. 3:1-57.
- Massey, B. W. 1972. Breeding biology of California least tern. M.A. thesis. Calif. State Univ., Long Beach, CA.
- Massey, B. W. 1974. Breeding biology of the California least tern. Proc. Linnaean Soc. 72:1-24.
- Massey, B.W. 1976. Vocal differences between American least terns and the European little tern. The Auk 93(4):760-773.
- Massey, B. W., and J. L. Atwood. 1978. Plumages of the least tern. Bird-Banding 49: 360-371.
- Massey, B. W., and J. L. Atwood. 1985. Application of ecological information to habitat management for the California least tern. Final Job Progress Rept. #7, U.S. Fish and Wildlife Service, Laguna Niguel, CA.
- McGinnis, S.M. 1992. Habitat requirements, distribution, and current status of the Alameda whipsnake (Masticophis lateralis euryxanthus). Report to the U.S. Fish and Wildlife Service. Sacramento, California. 26pp.
- Meng, L. 1993. Status of Sacramento splittail and longfin smelt. Report submitted to U.S. Fish and Wildlife Service, August 1993.
- Meng, L. and P.B. Moyle. 1995. Status of Sacramento splittail in the Sacramento-San Joaquin Estuary. Transactions of the American Fisheries Society. 124:538-549.
- Moffitt, J. 1941. Notes on the food of the California clapper rail. Condor 43:270-273.
- Monroe, M.W. and J. Kelly 1992. State of the Estuary: A report on conditions and problems in the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. San Francisco Estuary Project, Oakland, California.
- Moyle, P.B. 1976. Inland Fishes of California. University of California Press, Berkeley, California. 405 pp.
- Moyle, P.B. 1998. In preparation: The revised Inland Fishes of California. University of California Press, Berkeley, California. 405 pp.

- Moyle, P. B., B. Herbold, D. E. Stevens, and L. W. Miller 1992. Life history and status of delta smelt in the Sacramento-San Joaquin Estuary, California. *Trans. Am. Fish. Soc.* 121:67-77.
- Moyle, P.B. and R. M. Yoshiyama 1992. Fishes, aquatic diversity management areas, and endangered species. A plan to protect California's native aquatic biota. Draft report prepared for California Policy Seminar, University of California, Berkeley, California. July 1992. 196 pp.
- Nakamoto, R.J. and T. Hassler. 1992. Selenium and other trace elements in bluegills from agricultural return flows in the San Joaquin Valley, CA. *Archives of Environmental Contamination and Toxicology* 22:88-98.
- National Marine Fisheries Service 1993. Biological opinion for the operation of the Federal Central Valley Project and the California State Water Project. February 12, 1993. 81 pages plus attachments.
- National Marine Fisheries Service 1995. Amendment to the February 12, 1993, biological opinion for the operation of the Federal Central Valley Project and the California State Water Project. May 17, 1995. 13 pages.
- Nichols, F.H., J.E. Cloern, S.N. Luoma, and D.H. Peterson 1986. The modification of an Estuary. *Science* 231:567-573.
- Ornduff, Robert. 1974. *Introduction to Plant Life*. University of California Press, Berkeley. 152 pp.
- Pennak, R.W. 1989. *Fresh-water invertebrates of the United States: Protozoa and mollusca*. 3rd Ed. 628 pp.
- Radtke, L. D. 1966. Distribution of smelt, juvenile sturgeon, and starry flounder in the Sacramento-San Joaquin Delta. Pp. 115-119 in J. L. Turner and D. W. Kelley, eds.: *Ecological studies of the Sacramento-San Joaquin Estuary, Part 2*. California Department of Fish and Game Fish Bulletin No. 136.
- Rossman, D.A., N. B. Ford, and R. A. Seigel. 1996. *The garter snakes: evolution and ecology*. University of Oklahoma Press, Norman and London.
- Rossman, D. A. and G. R. Stewart. 1987. Taxonomic reevaluation of *Thamnophis couchii*. *Occasional Papers of the Museum of Zoology, Louisiana State University*, No. 63, 23 pp.
- Rutter, C. 1908. The fishes of the Sacramento-San Joaquin basin, with a study of their distribution and variation. *Bulletin of U.S. Bureau of Fisheries* 27(637):103-152.

- Simovich, M.A. and M. Fugate. 1992. Branchiopod diversity in San Diego County, California. 1992 Transactions of the Western Section of the Wildlife Society 28:6-14.
- Sommer, T., R. Baxter and B. Herbold. 1997. Resilience of splittail in the Sacramento-San Joaquin Estuary. Transactions of the American Fisheries Society. 126:961-976.
- Stebbins, R.C. 1985. A field guide to western reptiles and amphibians. Houghton Mifflin Company, Boston, MA. xiv + 336 pp.
- Stevens, D. E., S. W. Miller, and B. C. Bolster 1990. Report to the Fish and Game Commission: A status review of the delta smelt (*Hypomesus transpacificus*) in California. California Department of Fish and Game Candidate Species Status Rept. 90-2. 149 pages.
- Storer, T.I. 1925. A synopsis of the amphibia of California. University of California Publications in Zoology 27:1-342.
- Swaim, K. E. 1994. Aspects of the ecology of the alameda whipsnake (*Masticophis lateralis euryxanthus*). Master's thesis. California State University at Hayward. 140 pp.
- Swanson, C. And J. J. Cech, Jr. 1995. Environmental tolerances and requirements of the delta smelt, *Hypomesus transpacificus*. Final Report. 77 pp.
- Swanson, G.A., M.I. Meyer and J.R. Serie. 1974. Feeding ecology of breeding blue-winged teals. J. Wild. Mang. 38:396-407.
- Sweetnam, D.A. and D.E. Stevens 1993. Report to the Fish and Game Commission: A status review of the delta smelt (*Hypomesus transpacificus*) in California. Candidate Species Status Report 93-DS. 98 pages plus appendices.
- Test, F.H., and A.R. Test. 1942. Food of the California clapper rail. Condor 44:228.
- U.S. Fish and Wildlife Service 1980. California Least Tern Recovery Plan. 58 pp.
- U.S. Fish and Wildlife Service. 1984. Salt marsh harvest mouse and California clapper rail recovery plan. Portland, Oregon. 141 pp.
- USFWS. 1992. Wetland losses within northern California from projects authorized under Nationwide Permit No. 26. Sacramento Field Office. Sacramento, California.
- U.S. Fish and Wildlife Service 1994. Formal consultation on the 1994 operation of the Central Valley Project and State Water Project: Effects on delta smelt. 34 pages, plus figures.

- U.S. Fish and Wildlife Service 1995. Formal consultation and conference on the effects of long-term operation of the Central Valley Project and State Water Project on the threatened delta smelt, delta smelt critical habitat, and proposed threatened Sacramento splittail. 52 pages, plus figures and attachment.
- U.S. Fish and Wildlife Service 1996. Sacramento-San Joaquin Delta Native Fishes Recovery Plan.
- U.S. Fish and Wildlife Service 1998. Recovery plan for arid upland and riparian species of the San Joaquin Valley, California. USFWS, Sacramento Field Office, Sacramento.
- U.S. Fish and Wildlife Service 1999. Issuance of Permits under Section 404 of the Clean Water Act or Authorizations under the Nationwide Permit Program for Projects that May Affect the California Red-legged Frog
- Varoujean, D.H. 1972. A study of the California clapper rail in Elkhorn Slough, 1972. Report to the California Dept. of Fish and Game. 9 pp.
- Wang, J.C.S. 1986. Fishes of the Sacramento-San Joaquin estuary and adjacent waters, California: A guide to the early life histories. Interagency Ecological Study Program for the Sacramento-San Joaquin Estuary. Tech. Rept. 9.
- Wang, J.C.S. 1991. Early life stages and early life history of the delta smelt, *Hypomesus transpacificus*, in the Sacramento-San Joaquin Estuary, with comparison of early life stages of the longfin smelt, *Spirinchus thaleichthys*. Interagency Ecological Studies Program for the Sacramento-San Joaquin Estuary. Tech. Rept. 28.
- Weihs, D. 1974. Energetic advantages of burst swimming of fish. J. Theor. Bio. 48:215-229.
- Williams, L. 1929. Notes on the feeding habits and behavior of the California clapper rail. Condor 31:52-56.
- Wright, A.H. and A.A. Wright. 1949. Handbook of frogs and toads of the United States and Canada. Comstock Publishing Company, Inc., Ithaca, NY. xii + 640 pp.
- Wylie, G. D., M. Cassaza, and J. K. Daugherty. 1997. 1996 Progress report for the giant garter snake study. Preliminary report, USGS, Biological Resources Division.
- Zedler, P.H. 1987. The ecology of southern California vernal pools: a community profile. U.S. Fish and Wildl. Serv. Biol. Rep. 85(7.11). 136 pp.

Delta Smelt(1-1-93-F-35)

(U.S. Fish and Wildlife Service September 9, 1993, with clarification on September 24, 1993)

It was our biological opinion that, assuming service area deliveries of up to 148,000 AFY, the proposed operation of the Los Vaqueros Project (LVP), based on requirements set forth in D-1485 and including modifications from the long-term CVP-OCAP biological opinion for the winter-run chinook salmon and the Los Vaqueros biological opinion for winter-run chinook salmon, would not likely jeopardize the continued existence of the delta smelt. Critical habitat for this species had not been designated; therefore, it was our biological opinion that none would be adversely modified or destroyed.

The delta smelt biological opinion requires CCWD to divert CVP water from the screened Old River intake as much as possible during the period January through August each year in lieu of using Rock Slough. CCWD will also shift pumping, consistent with its water quality goals, to the intake(s) that provide the greatest fishery protection. This is accomplished through a fish monitoring program, designated and approved through the Biological Opinions. CCWD's operations also provide new fisheries benefits and protections. The release of blending water from the Los Vaqueros Reservoir to meet CCWD's delivered water quality objectives, and the existing limitations on refilling the reservoir under the delta smelt and winter-run biological opinions, reduce CCWD's diversions from the Delta in drier periods when water quality is poor and flows are low. Normal refilling of the reservoir generally occurs when there are both higher Delta flows and good water quality in the Delta and when impacts to fisheries are reduced. Additionally, under the Los Vaqueros biological opinions, CCWD is required to cease all diversions from the Delta for 30 days each Spring if stored water is available in Los Vaqueros Reservoir above emergency storage levels and to use releases from the reservoir to meet CCWD demands. These operations with the LVP provide net benefits to Delta fisheries.

San Joaquin Kit Fox and Bald Eagle (1-1-92-F-42)

(U.S. Fish and Wildlife Service September 3, 1993)

It was our biological opinion that the authorization of construction and operation of the LVP would not jeopardize the continued existence of the endangered San Joaquin kit fox or bald eagle. Critical habitat for these species had not been identified; therefore it was our biological opinion that none would be destroyed nor adversely modified.

CCWD and Reclamation have continued to meet the requirements set forth in the biological opinion with respect to the Interim Service Area Program (ISAP). The purpose of the ISAP is for CCWD and Reclamation to apply measures within its authority to help ensure that new development in the CCWD service area does not result in unauthorized take of federally listed species. Under the ISAP, CCWD has agreed to:

- a. prepare and annually update baseline maps to indicate the known distribution and potential habitats of species listed or proposed for listing under the federal ESA within the service area; provide baseline maps to all agencies having land use authority in the service area, DFG, and the Service;
- b. formally request that agencies having land use authority in the service area provide CCWD with any notice of preparation, draft categorical exemptions, draft negative declaration, or draft EIR for any proposed ground-disturbing actions, including new developments;
- c. provide comments on these environmental documents to the lead agencies (with copies to the Service and Reclamation), including an initial assessment of whether a proposed action is within the range of a species protected under the Act and stating that the agencies should attest to or require a demonstration by developers of compliance with the Act; and
- d. if a proposed project is within the range of species protected under the Act, encourage the project proponent to coordinate with the Service to determine the type and extent of surveys needed to be conducted for the Service's review.

The program, therefore, ensures that land use jurisdictions are aware of potential endangered species issues and that the Service is notified of projects that may affect listed and proposed species. Implementation of the ISAP reduces the likelihood for secondary effects of growth on species protected under the ESA to the greatest extent legally possible under CCWD's authority. Primary land use agencies, however, maintain legal authority for ensuring that appropriate mitigation measures will be developed and implemented that reduce potential impacts on listed and proposed species to a less-than-significant level.

The data developed under the ISAP has been used in the evaluation of impacts to federally threatened and endangered species as presented in the FWSI FEIR and the Biological Assessment.

California Red-Legged Frog (1-1-96-F-151)
(U.S. Fish and Wildlife Service, November 8, 1996)

It was our biological opinion that the effects of the LVP reservoir, and all ancillary facilities, management and operations relative to the reservoir site, recreational use of the LVP and cumulative effects would not jeopardize the continued existence of the endangered California red-legged frog (see the biological opinion attached as appendix Cd. Critical habitat for the species had not been identified nor proposed; therefore it was our biological opinion that none would be affected.

Fairy Shrimp Species (1-1-95-F-117)
(U.S. Fish and Wildlife Service, August 7, 1995)

The Service issued a non-jeopardy conference opinion on September 2, 1993. Subsequently, the longhorn fairy shrimp and the vernal pool fairy shrimp were listed as endangered and threatened, respectively. In 1995, the Service reaffirmed that the LVP was not likely to jeopardize the continued existence of these two fairy shrimp species, and adopted the conference opinion, along with certain agreed upon changes to terms and conditions, as our biological opinion.

Winter-Run Chinook Salmon
(National Marine Fisheries Service, March 18, 1993)

NMFS determined that operation of the LVP, including the existing Rock Slough intake, was not likely to jeopardize the continued existence of winter-run chinook salmon or result in the destruction or adverse modification of its critical habitat. The biological assessment supporting the opinion addressed impacts related to increasing diversions from the then existing level (130,000 to 140,000 acre feet/year) to full build out (195,000 acre feet/year).

Table 4. CONTRA COSTA WATER DISTRICT:
SUMMARY AND STATUS OF REQUIREMENTS OF USFWS'
LOS VAQUEROS PROJECT BIOLOGICAL OPINIONS (BO)

BO Term and Condition	Summary Requirement	Status		Comments
		Completed	Ongoing	
ALAMEDA WHIPSNAKE (11/8/96 Conference Report (CR) - Biological Opinion Requested by Reclamation in June 1998)				
a.	Alameda Whipsnake shall be incorporated in the "Interim Service Area" program.	✓		
b.	The "Interim Service Area" program maps and database shall incorporate Alameda Whipsnake.	✓		
c.	Submit a fire management plan to USFWS.	✓		The plan was a part of the Watershed Management Plan (WMP) reviewed by USFWS in 1998.
d.	USFWS must approve any new fire management methods that were not addressed in the fire management plan.		✓	
e.	No construction activities or recreation uses or facilities may be located within 500 ft. of chaparral or scrub.		✓	
f.	Maintenance activities within 500 ft. of chaparral or scrub shall be limited to existing roads. No off-road activities in this habitat unless USFWS approved.		✓	
g.	Speed limits on existing roads within this habitat shall be 15 mph.		✓	
h.	No additional fire breaks shall be constructed within this habitat unless USFWS approves.		✓	

Table 4. CONTRA COSTA WATER DISTRICT: (Continued)
SUMMARY AND STATUS OF REQUIREMENTS OF USFWS'
LOS VAQUEROS PROJECT BIOLOGICAL OPINIONS (BO)

BO Term and Condition	Summary Requirement	Status		Comments
		Completed	Ongoing	
BALD EAGLE (9/3/93)				
4. ^a	Recreation Plan to be approved by USFWS.			Plan submitted to USFWS for comment.
5.	CCWD to conduct 5 years post operation monitoring regarding wind turbine mortality and recreation impacts.	✓		USFWS approved monitoring studies plans in 1998. Annual report.
DELTA SMELT (9/3/93, as clarified by letters of 9/24/93, 2/20/97)				
1ai.	Restrictions on timing of diversions to fill the reservoir are described.	✓		
1aii.	The schedule for initial reservoir filling shall be submitted to USFWS for approval.	✓		
1b.	After initial filling an annual filling schedule will be submitted to USFWS, NMFS and DFG by January 1st. The agencies may alter the proposed schedule.	✓		
1c.	USFWS must approve a fish sampling study plan. The plan shall be implemented and results reported annually.	✓	✓	Plan was approved and is being implemented.

^a Terms and Conditions 1-3 relate to Kit Fox and are discussed elsewhere in this table.

Table 4. CONTRA COSTA WATER DISTRICT: (Continued)
SUMMARY AND STATUS OF REQUIREMENTS OF USFWS'
LOS VAQUEROS PROJECT BIOLOGICAL OPINIONS (BO)

BO Term and Condition	Summary Requirement	Status		Comments
		Completed	Ongoing	
DELTA SMELT (cont.)				
1d.	Real-time fish monitoring shall be conducted.	✓		This requirement was modified and replaced by other methods.
1e.	Use results from 1d, above, to determine diversion intake source to reduce take.		✓	"
1f.	Report results of monitoring annually.		✓	
2a.	With Reclamation, screen Rock Slough intake by October 1998. Conduct screen velocity, screen cleaning performance before operation.		✓	This program is well underway. Date postponed temporarily with USFWS approval.
2b.	Old River intake shall be screened prior to its operation. Conduct screen cleaning performance testing for agencies approval.	✓		
3a.	Use best management practices during construction to reduce take potential. Replace lost spawning habitat at 3:1 ratio.	✓		Construction complete. No spawning habitat was impacted. USFWS agreed that no habitat compensation is required.
3b.	CVP water shall be diverted from Old River unless other points of diversion are approved by USFWS.		✓	As clarified, construction of Mallard Slough screens is not required so long as the intake is operated as in the past (clarification letter 9/24/93).

Table 4. CONTRA COSTA WATER DISTRICT: (Continued)
SUMMARY AND STATUS OF REQUIREMENTS OF USFWS'
LOS VAQUEROS PROJECT BIOLOGICAL OPINIONS (BO)

BO Term and Condition	Summary Requirement	Status		Comments
		Completed	Ongoing	
FAIRY SHRIMP (8/7/95)				
1a.	Restrict public access to Kellogg Creek vernal pool. Control public access to east side of reservoir.		✓	Recreation Plan previously submitted to USFWS conforms with this requirement.
1b.	Relocate eastern shore boat-in camp unless approved by USFWS.		✓	Recreation Plan previously submitted to USFWS conforms with this requirement.
2a.	The Kellogg Creek vernal pool will be located within kit fox conservation easement areas.	✓		
2b.	Acquire Vasco Caves area and, with EBRPD, manage to protect sensitive resources.	✓		
3a.	Implement all mitigation for fairy shrimp as listed in the EIR/EIS.		✓	
3b.	Conduct pre-construction surveys within 0.5 mile of construction and protect any vernal pools if found.	✓		
3c.	Seasonal restrictions on construction withdrawn. Additional take authorized.	✓		No take of habitat occurred during construction.
3d.	A qualified monitor will help protect habitat during construction.	✓		

Table 4. CONTRA COSTA WATER DISTRICT: (Continued)
SUMMARY AND STATUS OF REQUIREMENTS OF USFWS'
LOS VAQUEROS PROJECT BIOLOGICAL OPINIONS (BO)

BO Term and Condition	Summary Requirement	Status		Comments
		Completed	Ongoing	
FAIRY SHRIMP (cont.)				
3e.	Vasco Road construction will avoid sensitive habitat.	✓		
3f.	Ensure no pesticides or other chemical agents are used within 200 ft. of sensitive habitat.		✓	
3g.	Ensure no trash dumping within sensitive habitat.		✓	
3h.	Construction dust will be controlled in the vicinity of vernal pools.	✓		
3i.	Fencing will be installed and inspected to protect the Kellogg Creek vernal pool from livestock and human intrusion.	✓		
3j.	Provide complete access in perpetuity to agencies for monitoring and enforcement.		✓	
4.	A worker orientation program will be implemented.	✓		Over 3,500 persons were oriented prior to their working on the project.
5.	The "Interim Service Area" program shall include listed shrimp species covered by this BO.	✓		

Table 4. CONTRA COSTA WATER DISTRICT: (Continued)
SUMMARY AND STATUS OF REQUIREMENTS OF USFWS'
LOS VAQUEROS PROJECT BIOLOGICAL OPINIONS (BO)

BO Term and Condition	Summary Requirement	Status		Comments
		Completed	Ongoing	
KIT FOX (9/3/93, as amended in 1995 and 1998)				
1.	Implement construction-related measures in USFWS 1989 standard procedures including a 20 mph nighttime speed limit and traffic restrictions at pp. 9-10 of the BO project description.	✓		Although completed during major project construction, these will apply again during construction of recreation facilities.
2.	Pre-construction hand-excavation of known/possible dens in accordance with USFWS 1989 standard procedures.	✓		As amended in 1995, completed during major construction and will be applied during construction of recreation facilities.
3.	Convey to the State of California Conservation Easements (CE) on suitable Kit fox habitat in a ratio of 3:1 (compensation: impact acres of "out-of-watershed" lands for mitigation areas 1 (Herdlyn) and 2 (a portion of Vasco Caves). Total acres to be conveyed are 6,513 which includes compensation for recreation facilities (including buffers) at build-out.	✓		Prior to construction, 4,150 acres were conveyed as CEs to compensate for all construction impacts. Conveyance of the balance of acres, including those for recreation-related impacts, was begun in 1998.
RED-LEGGED FROG (RLF) (11/8/96)				
1a.	Include RLF in "Interim Service Area" program.	✓		
1b.	Provide service area maps and database.	✓		
2a.	RLF habitat shall be maintained or replaced over time.		✓	Subject of annual reporting.

Table 4. CONTRA COSTA WATER DISTRICT: (Continued)
SUMMARY AND STATUS OF REQUIREMENTS OF USFWS'
LOS VAQUEROS PROJECT BIOLOGICAL OPINIONS (BO)

BO Term and Condition	Summary Requirement	Status		Comments
		Completed	Ongoing	
RED-LEGGED FROG (RLF) (cont.)				
2b.	Cannot eliminate stockponds without USFWS approval.		✓	See approved Predator Control Plan for permission to remove four ponds.
2c.	If necessary, water will be artificially provided to RLF habitat.		✓	Subject of annual reporting.
2d.	If 2c., above, is required—ensure good water quality.		✓	
2e.	Construct fencing as planned.	✓		
2f.	Design new wetlands to hold water until October 1st in mean water years.	✓		
2g.	Restricts mitigation pond maintenance scheduling.		✓	
2h.	Monitor habitat maintenance downstream of dam.		✓	Subject of annual reporting.
2i.	Prescription for new wetlands planting.	✓		
	Performance monitoring required.		✓	Subject of annual reporting.
2j.	Prescription for new wetlands design.	✓		
2k.	USFWS must approve changes to mitigation habitat management.		✓	Subject of annual reporting.

Table 4. CONTRA COSTA WATER DISTRICT: (Continued)
SUMMARY AND STATUS OF REQUIREMENTS OF USFWS'
LOS VAQUEROS PROJECT BIOLOGICAL OPINIONS (BO)

BO Term and Condition	Summary Requirement	Status		Comments
		Completed	Ongoing	
RED-LEGGED FROG (RLF) (cont.)				
2l.	Mitigation fencing, estivation boxes, willow planting to be in place prior to reservoir filling.	✓		Field review by USFWS in December 1997.
2m.	Prescription for inoculation-fertilization program.	✓		
2n.	Plant willows at estivation boxes.	✓		
2o.	Monitor all mitigation habitat annually for RLF and bullfrog.		✓	Monitoring Plan approved by USFWS in 1997. Subject of annual reporting.
2p.	Provide notice to USFWS prior to relocation of RLF.		✓	
2q.	Partially fence four ponds on Jackson property.	✓		
2r.	Provide Monitoring Plan to USFWS for approval.	✓		Plan approved by USFWS in 1997.
2s.	Fence habitat corridors in Units D, F, and G.	✓		Field review by USFWS in December 1997.
2t.	Inspect mitigation fencing regularly.		✓	
2u.	Continue grazing program at current levels unless approved by USFWS		✓	Grazing plan in Watershed Management Plan (WMP) reviewed by USFWS in 1997.

Table 4. CONTRA COSTA WATER DISTRICT: (Continued)
SUMMARY AND STATUS OF REQUIREMENTS OF USFWS'
LOS VAQUEROS PROJECT BIOLOGICAL OPINIONS (BO)

BO Term and Condition	Summary Requirement	Status		Comments
		Completed	Ongoing	
RED-LEGGED FROG (RLF) (cont.)				
3a.	Manage predators in mitigation areas.		✓	Predator Control Plan (PCP) approved by USFWS in 1997.
3b.	Drain ponds D7, F4, F8, and J4 by every September 15th until October 15th.		✓	See PCP for alternative method of control; Ponds may be eliminated.
3c.	Provide Predator Control Plan for USFWS approval.	✓		PCP approved by USFWS in 1997.
3d.	Implement PCP.		✓	
3e.	Control emergent vegetation along reservoir margins.		✓	See PCP for approved methods.
3f.	Obtain rotenone application permits within 2 years of filling reservoir.			No longer required. See approved PCP for alternative methods.
3g.	Monitor and remove any bullfrog egg masses in Spring.		✓	
3h.	By January 15th of each year provide annual monitoring report.		✓	
3i.	Must maintain readiness to drain all stockpounds between September 15 and October 30, if predator control is needed.		✓	

Table 4. CONTRA COSTA WATER DISTRICT: (Continued)
SUMMARY AND STATUS OF REQUIREMENTS OF USFWS'
LOS VAQUEROS PROJECT BIOLOGICAL OPINIONS (BO)

BO Term and Condition	Summary Requirement	Status		Comments
		Completed	Ongoing	
RED-LEGGED FROG (RLF) (cont.)				
3j.	Should other predator control methods fail, permanent facilities for seasonal pond drainage shall be installed.			Possible future action.
4a.	RLF handling shall only be done under supervision of qualified, permitted personnel.			The BO provides handling authority to CCWD.
4b.	Only USFWS-approved temporary fencing shall be used for construction area exclosures.	✓		Fencing methods approved by USFWS in 1997.
4c.	The fencing described in 4b., above, shall be inspected daily, as needed.		✓	
4d.	The fencing described in 4b., above, shall be in place as long as needed.		✓	
4e.	Refueling of vehicles is prohibited in vicinity of mitigation habitat.		✓	
4f.	Notify USFWS 45 days in advance of RLF relocation.		✓	
4g.	Within 7 days of RLF relocation, provide map to USFWS showing origin and relocation locations.		✓	
4h.	Provide information on RLF and sensitive habitat restrictions to visitors.		✓	

Table 4. CONTRA COSTA WATER DISTRICT: (Continued)
SUMMARY AND STATUS OF REQUIREMENTS OF USFWS'
LOS VAQUEROS PROJECT BIOLOGICAL OPINIONS (BO)

BO Term and Condition	Summary Requirement	Status		Comments
		Completed	Ongoing	
RED-LEGGED FROG (RLF) (cont.)				
4i.	Monitor and report any take.		✓	
5a.	Provide conservation easements on RLF mitigation areas.			In 1997 USFWS agreed that conservation easements would not be required but reserved rights to impose this requirement in future.
5b.	Changes in land uses in the watershed from those described in the WMP or Recreation Plan shall be approved by USFWS.		✓	
5c.	Visitor use shall be limited and pets prohibited from mitigation management Units D, E, F and G.		✓	
5d.	Unless ponds are naturally dry, pond maintenance prohibited except from September 15th – October 30th.		✓	
5e.	Grazing levels shall continue at current levels.		✓	Grazing levels approved by USFWS in 1997 as described in Watershed Management Plan (WMP).
5f.	Recreation activities prohibited in RLF mitigation areas.		✓	
5g.	USFWS shall approve the Recreation Plan to ensure RLF habitat protection.			Plan submitted to USFWS for comments.

Table 4. CONTRA COSTA WATER DISTRICT: (Continued)
SUMMARY AND STATUS OF REQUIREMENTS OF USFWS*
LOS VAQUEROS PROJECT BIOLOGICAL OPINIONS (BO)

BO Term and Condition	Summary Requirement	Status		Comments
		Completed	Ongoing	
RED-LEGGED FROG (RLF) (cont.)				
5h.	Prohibition on fishing and release of aquatic organisms in RLF habitat.		✓	
5i.	Reclamation shall ensure (by endowment if needed) that the RLF mitigation program is maintained in perpetuity.		✓	
5j.	Herbicide/pesticide uses in the project area to be approved by USFWS.		✓	
5k.	USFWS shall approve the Predator Control Plan (PCP).	✓		USFWS approved the PCP in 1997.
5l.	USFWS must approve any plans for mosquito abatement.		✓	
5m.	USFWS must approve the Watershed Management Plan (WMP) and Recreation Plan.			USFWS approved the WMP in 1997. The Recreation Plan has been submitted to USFWS for comment.

EXISTING CVP OCAP BIOLOGICAL OPINIONS

Delta smelt (1-1-93-F-35)

(U.S. Fish and Wildlife Service, March 6, 1995)

This Biological Opinion required the CVP and State Water Project (SWP) to meet various protective measures in an effort to avoid adverse impacts on Delta smelt. Those measures include meeting the flows and export limits as set forth in the December 15, 1994 Delta Accord. In addition, the opinion established, through the CALFED Ops Group, additional pumping restrictions based on take levels. Also included were additional objectives related to San Joaquin River flows.

The March 6, 1995 non-jeopardy biological opinion established critical habitat requirements for the Delta smelt as follows.

Spawning habitat: includes Barker, Lindsey, Cache, Prospect, Georgiana, Beaver, Hog, and Sycamore sloughs and the Sacramento River in the Delta, and tributaries of the northern Suisun Bay. The spawning season was identified as variable beginning as early as December and extending as late as July.

Larval and juvenile transport: the biological opinion identifies adequate river flows as necessary to transport larvae from upstream spawning grounds to rearing habitat in Suisun. To maintain this function X2 is required west of the confluence during the transport period and may be required as early as February 1st and as late as August 31st.

Rearing habitat: The biological opinion identifies the area extending east from Carquinez Straits, including Suisun, Grizzly and Honker Bays, up the Sacramento River to the confluence with Three Mile slough, and south along the San Joaquin, including Big Break. The protection of this habitat may be required from the beginning of February through the end of August.

In addition to establishing critical habitat for the Delta smelt, the biological opinion identified water quality standards and operational constraints that are intended to provide biological benefits to the species. These include: 1) a minimum monthly average net Delta outflow which varies by water year type; 2) X2 protection in required number of days at Chipps and Port Chicago during the February through June period, to vary by PMI; 3) required San Joaquin flows at Vernalis varying by water year type; 4) closure of the Delta Cross Channel for a maximum of 45 days between November and January; 5) combined Delta exports not to exceed 1500 cfs during the spring pulse flow period; 6) a 35% E/I ratio from February through June and 65% E/I ratio July through January; 7) daily export limits based on average daily inflow; and, 8) use of operational flexibility to increase or decrease exports inline with ensuring biological protection.

Sacramento Splittail

As indicated above, the proposed protective actions on behalf of the Delta smelt will consequently assist in reversing the decline of the Sacramento splittail population. Most of the factors that have led to the decline of Delta smelt in the Estuary have also led to the decline of the splittail (i.e., diversion, dams, reduced outflow, drought periods, exotic species, etc.)

The splittail utilizes habitats in the Delta, Suisun Bay, Suisun Marsh, and the Yolo Bypass. The lifehistory characteristics can be summarized as such: Adults migrate from brackish water upstream into freshwater to spawn in the late fall and early winter; the onset of spawning can be triggered by increase in run-off and water temperatures, seasonal photoperiod, and can occur during the January through July timeframe. Larvae remain in shallow water moving downstream to brackish waters as they mature.

Winter Run Salmon

(National Marine Fisheries Service, May 17, 1995)

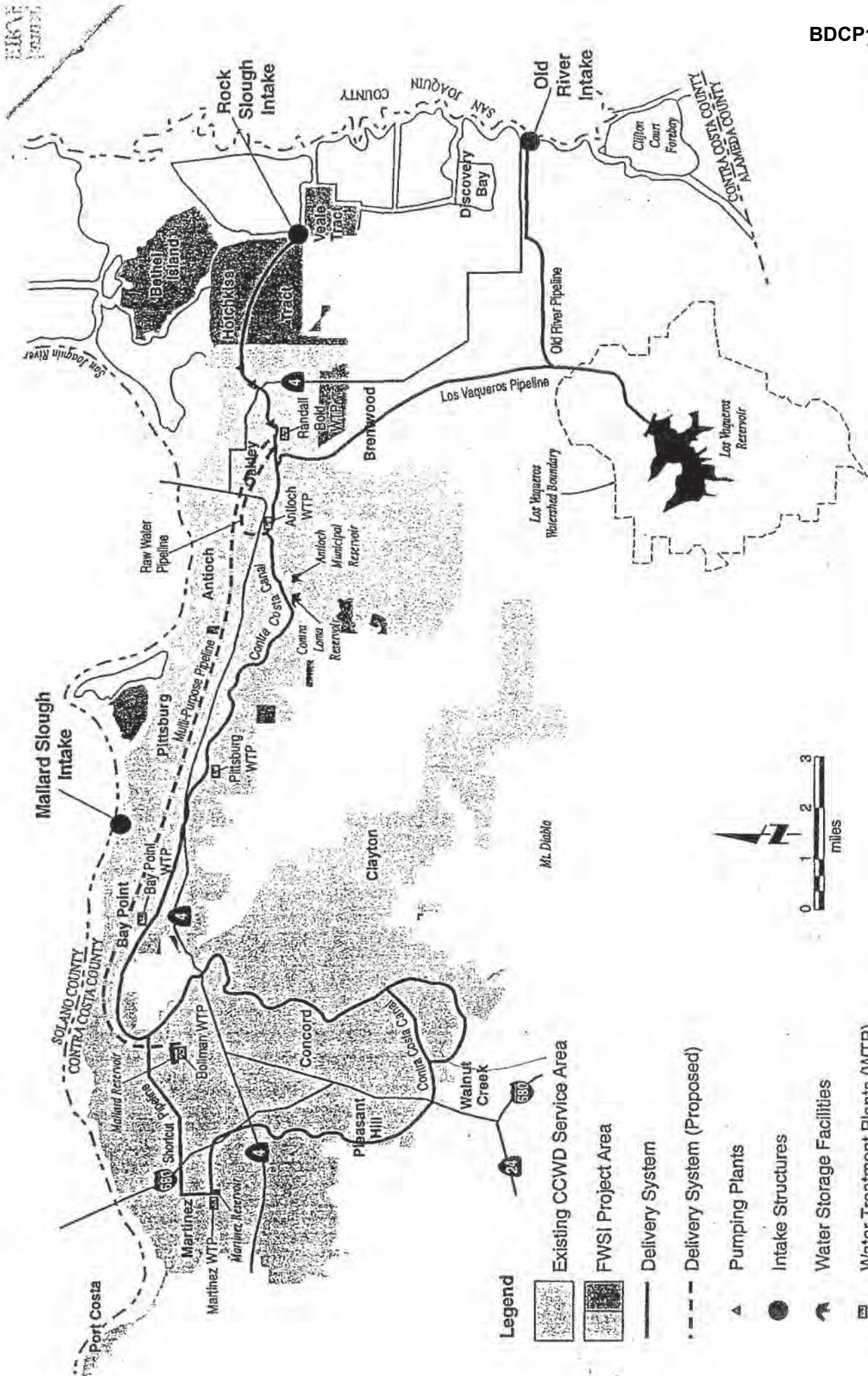
The National Marine Fisheries Service listed the winter-run chinook salmon as threatened in November 1990 and then changed that classification to endangered on June 19, 1992. The State of California listed the winter-run as endangered in 1989. NMFS also proposed critical habitat for the winter-run from Keswick Dam on the Sacramento River to the Golden Gate Bridge in 1992. In May 1995 NMFS issued a non-jeopardy opinion for operation of the CVP and SWP that specifies requirements including meeting flows and export limits in the December 15, 1994 Delta Accord, and export limits to protect winter run chinook salmon as provided through the CALFED Ops group.

Steelhead (NMFS)

The National Marine Fisheries Service listed the North Coast steelhead as threatened under the Endangered Species Act on March 13, 1998. As opposed to developing a regulatory approach to managing the species, NMFS decided to combine efforts with the State of California in developing conservation plans. This decision was due largely to habitat restoration efforts and other actions currently underway as part of the CALFED program that will improve conditions and reduce risks for steelhead in Central Valley streams. NMFS will bear the responsibility of providing protection until state and local conservation plans are developed and initiatives are in place.

Attachment 4

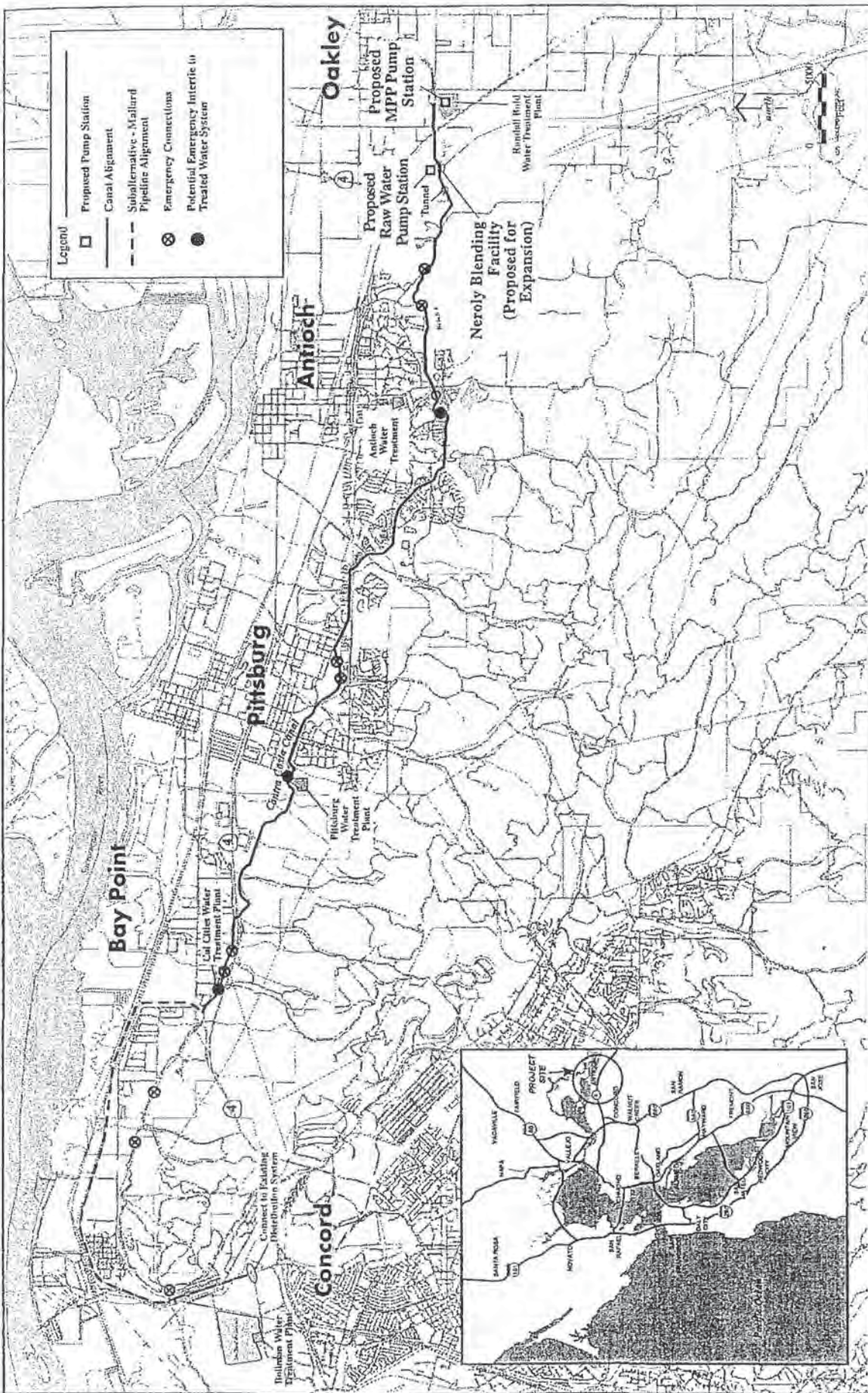
(Dennis M. has a copy)



CCWD Service Area and Facilities

Figure 1





SOURCE: Camp Dresser & McKee, Inc.; Environmental Sciences Associates

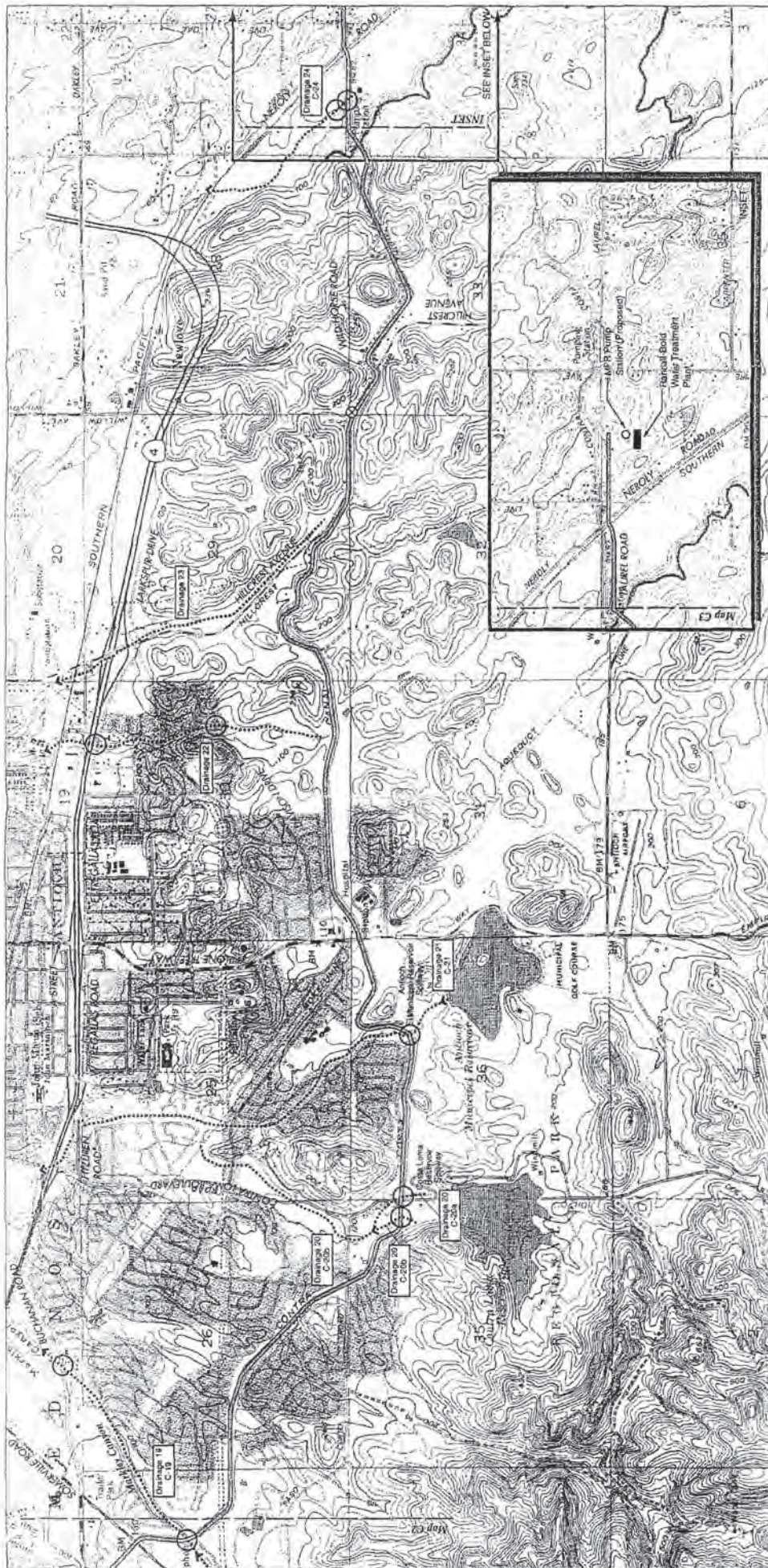
Multi-Purpose Pipeline Project
Proposed Location and Proposed Facilities

Figure 2



Multi-Purpose Pipeline Project
Proposed Facilities and Drainages and Wetlands in the Project Vicinity

Figure 3A



0 2000
Feet

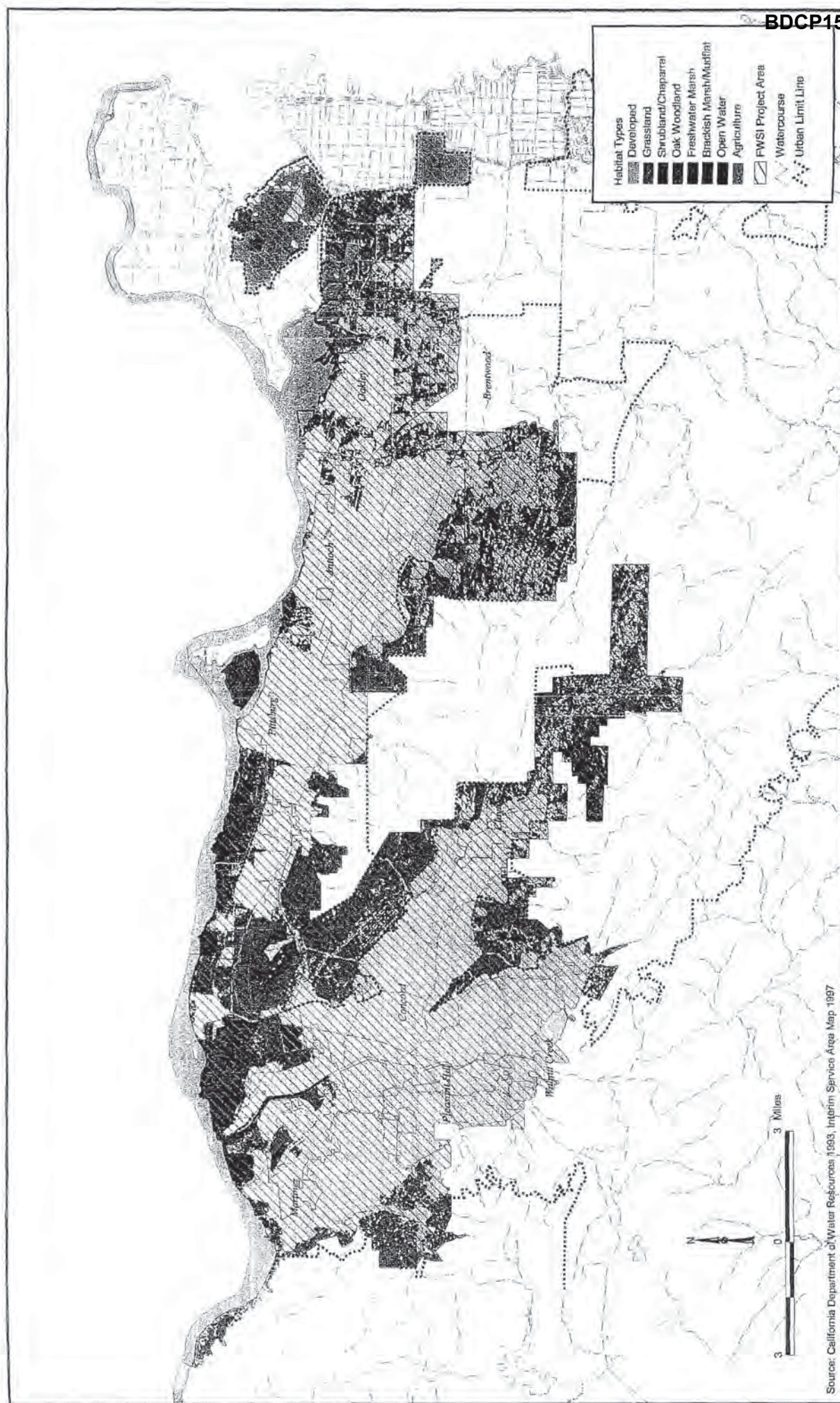
Coal Alignment
Emergency Connection

Wetlands
Drainage Crossings (above ground courses)
M=Mailroad Alignment; C=Canal Alignment

SOURCE: Environmental Science Associates



Jones & Stokes Associates, Inc.



Source: California Department of Water Resources 1993, Interim Service Area Map 1997



United States Department of the Interior
FISH AND WILDLIFE SERVICE
Sacramento Fish and Wildlife Office
2800 Cottage Way, Room W-2605
Sacramento, California 95825-1846



IN REPLY REFER TO:
1-1-04-F-0082

11 March 2005

Memorandum

To: Chief, Resource Management Division, U.S. Bureau of Reclamation, South Central California Area Office, Fresno, California (Attn.: Kathy Wood)

From: Acting Field Supervisor, Sacramento Fish and Wildlife Office, Sacramento, California *Kathy Wood*

Subject: Reinitiation and Amendment of Formal Consultation and Conference on Contra Costa Water District's Future Water Supply Implementation Program (Service file no. 1-1-99-F-0093) for the Renewal of the Central Valley Project Long Term Water Service Contract, Contra Costa County, California

This document transmits the Fish and Wildlife Service's biological opinion based on our review of the proposed renewal for 40 years of Contra Costa Water District's (CCWD) Central Valley Project (CVP) water service contract in Contra Costa County, California in accordance to section 7 of the Endangered Species Act (Act) of 1973, as amended. Your letter was received in our office on April 5, 2004. Formal consultation was initiated on April 5, 2004.

This biological opinion is based on 1) Reclamation's final biological assessment dated March 31, 2004; 2) biological opinion 1-1-99-F-0093, which authorized CCWD's construction of a multipurpose pipeline and Future Water Supply Implementation Program (U.S. Fish and Wildlife Service 2000a); 3) biological opinion 1-1-04-F-0140, which addressed the effects of delivering CVP water to the contractors, including CCWD (U.S. Fish and Wildlife Service 2004a); 4) numerous e-mails, telephone calls, and meetings between Service staff and staff from Reclamation, and; 5) information in Service files. Supporting information for this consultation is on file in the SF-WO.

BACKGROUND

On April 27, 2000, the Service issued biological opinion 1-1-99-F-0093, which authorized CCWD's construction of a multipurpose pipeline as part of a Future Water Supply Implementation Program (U.S. Fish and Wildlife Service 2000a). The central elements of the Future Water Supply Implementation Program (FWSIP) are (1) the renegotiation and renewal of CCWD's Central Valley Project (CVP) water service contract; (2) implementation of a

TAKE PRIDE
IN AMERICA

Regional Director

2

conservation program for the area that will receive Federal water under the FWSIP; and (3) the purchase of water transfers to accommodate near-term drought needs and future growth.

The biological opinion that we issued on construction of the multi-purpose pipeline and implementation of the FWSIP addressed the effects of the construction, maintenance and operation of a multipurpose pipeline and continued delivery of water based on current operation parameters. In addition, that biological opinion analyzed the effects of the secondary urban growth and development resulting from 219,400 acre feet of water annually (afa) from a combination of 195,000 afa Central Valley Project (CVP) water delivery, additional surface water rights, transferred surface water, groundwater sources and water conservation (collectively referred to as the Future Water Supply Implementation Program (FWSIP)).

In that biological opinion the Service concluded that the federally endangered vernal pool tadpole shrimp (*Leptodurus packardii*), salt marsh harvest mouse (*Reithrodontomys raviventris*), California least tern (*Sterna anillarum* (=albifrons) *brownii*), California clapper rail (*Rallus longirostris*), soft bird's-beak (*Corydallanthus mollis* ssp. *mollis*), Contra Costa goldfields (*Lasthenia confertiflora*), San Joaquin kit fox (*Vulpes macrotis mitchellii*), and longhorn fairy shrimp (*Branchinecta longiantenna*), and the federally threatened giant garter snake (*Thamnophis gigas*), vernal pool fairy shrimp (*B. lynchi*), Alameda whipsnake (*Masticophis lateralis euryanthis*), and California red-legged frog (*Rana aurora draytoni*) are not likely to be jeopardized by the effects of construction of the Multi-purpose pipeline, including delivery and application of CVP contract water. That biological opinion exempted take associated with construction of the Multipurpose Pipeline and did not exempt take associated with indirect effects of urban development associated with the FWSIP.

As part of the consultation on the FWSIP, CCWD proposed conservation measures that were pivotal to the Service's conclusion that the indirect effects of future water deliveries would not jeopardize the continued existence of federally listed species. Those conservation measures included the following: 1) CCWD would participate in a Habitat Conservation Plan (HCP) for east Contra Costa County, and contribute up to \$300,000 to fund development of the HCP. Until completion of the HCP, CCWD would limit water delivery to 148,000 acre-feet per year (afa) to the CCWD service area; 2) Purchase water supplies to accommodate urban growth incrementally so that growth is not encouraged beyond that which is already planned and permitted by local land use agencies with land use authority, and establish a monitoring process to track the impact of new development on water demand projections and available projected water supplies; 3) Enforce CCWD Code of Regulations section 5.04.120, which requires proponents for an annexation or applicants for water service to newly annexed lands to provide all necessary environmental documentation and approvals by the appropriate regulatory agencies, including the Service, before CVP water can be provided.

Reinitiation of the Original Consultation

We are reinitiating consultation on the original action as elements of the FWSIP have come to fruition or have evolved. For example, Reclamation now proposes to renew the CVP water service contract for CCWD for a period of 40 years. CCWD had previously been operating

BDCP1563.

under an existing Amended Contract with Reclamation, dated 1994. The CCWD's 1994 Amended Contract for CVP water provides for the operation of the Los Vaqueros Project and states that Reclamation will annually supply up to 195,000 af of CVP water to the CCWD, with a reduction in deliveries during water shortages including regulatory restricted, and drought years. The Amended Contract expires on December 31, 2010. CCWD's agreement to limit water diversions to 148,000 af until the HCP is completed apply to diversions under the Amended Contract, and will continue to apply to a renewed CVP contract. By "completion of the HCP", we mean until such time the Service issues a permit in accordance with the provisions of section 10(a)(1)(B) of the Endangered Species Act for an HCP that covers take of listed species incidental to future urban, commercial, and industrial development within currently undeveloped areas of the CCWD water service area.

To comply with the above, Reclamation and CCWD have done the following:

- 1) The East Contra Costa County HCP is nearing completion and anticipated to be signed and the Section 10 permit(s) issued in the spring of 2005. This HCP will cover the undeveloped areas within CCWD's service area and other areas of East Contra Costa County, with the exception of the City of Antioch, which has chosen not to participate in the HCP. On February 18, 2005, CCWD submitted a letter clarifying their position on operation and maintenance (O&M) of habitat conservation plan (HCP) lands. CCWD committed to provide a competitive proposal to perform O&M services for the HCP on a contract basis – if requested to do so by the HCP implementing entity.
- 2) Reclamation's March 31, 2004, biological assessment outlined the status of Reclamation and CCWD commitments under the Act, including the Los Vaqueros Project biological opinions. In addition, Reclamation and the Service have agreed to a plan to address the construction of the fish protection facility at Rock Slough (Service file #1-1-04-F-0034, Reinitiation of Formal Endangered Species Consultation and Amendment to the Los Vaqueros Biological Opinion (Service File No.: 1-1-93-F-35), dated December 10, 2003).
- 3) Reclamation is in the process of renewing all long term CVP water contracts. All long-term CVP water contracts will undergo separate section 7 consultations, and will review changes that may be proposed as part of the contract renewals that have not already been addressed by earlier biological opinions.
- 4) Reclamation's renewal of approximately 200 long-term water service contracts, the Trinity Decision, Delta Wetlands, and P.L. 101-514, all required reinitiation of the 1995 biological opinion on the Operational Criteria and Plan (OCAP) on the basis that the additive effects of these new actions have not been previously analyzed. The reinitiated OCAP consultation analyzed the effects of numerous new actions on the federally threatened delta smelt (*Hypomesus transpacificus*) and its designated critical habitat. On July 30, 2004, the Service issued biological opinion 1-1-04-F-0140, which analyzed and addressed the effects to delta smelt and its designated critical habitat resulting from the delivery of CVP and SWP water to water contractor's points of diversion, including CCWD (U.S. Fish and Wildlife Service 2004a). On February 15, 2005, the Service issued biological opinion 1-1-05-F-0055 in response to

Reclamation's November 3, 2004 request for reinitiation of formal consultation on the OCAP to analyze the effects of the OCAP on delta smelt critical habitat in light of current case law on the Service's definition of "adverse modification". Therefore, this reinitiation and amendment of formal consultation and conference of biological opinion 1-1-99-F-0093 does not include a reanalysis of effects on delta smelt or its designated critical habitat, and all portions of biological opinion 1-1-99-F-0093 which pertain to delta smelt or its designated critical habitat are superseded by biological opinion 1-1-04-F-0140. Our February 15, 2005, biological opinion on OCAP is hereby incorporated by reference.

The consultation history of biological opinion 1-1-99-F-0093 is supplemented as follows:

In November 2000, the Service issued a *Biological Opinion on the Implementation of the Central Valley Project Improvement Act and Continued Operation and Maintenance of the Central Valley Project* (CVPIA programmatic biological opinion). The CVPIA biological opinion programmatic addressed both the operation and maintenance of the CVP and implementation of the CVPIA. Because the 2000 CVPIA biological opinion is a programmatic document, subsequent site-specific evaluations must be prepared to analyze the effects of implementing specific actions of the CVPIA on listed species. Replacing the existing Amended Contract with the proposed long-term water service contract is an action requiring site-specific evaluation.

The ESA commitments required under existing biological opinions that the Service has outlined for Reclamation and the CCWD are summarized in Appendix A of the biological assessment (U.S. Bureau of Reclamation 2004). Appendix B summarizes the ongoing and initiated projects and accomplishments of Reclamation's South-Central California Area Office. Appendix B also includes a map of CVP service areas for long-term water service contract renewals that are under the purview of the South-Central California Area Office.

The consultations listed below comprise the consultation of CVP operation and water deliveries that comprise part of the consultation history for the proposed long term contract renewal:

- February 12, 1993–Long Term Operations Criteria and Plan (OCAP) for CVP Reservoirs (Service File 1-1-93-F-10); bald eagle, salt marsh harvest mouse, California clapper rail.
- May 23, 1993–OCAP (Service File 1-1-92-F-18); bald eagle, salt marsh harvest mouse, California clapper rail.
- May 26, 1993–1993 OCAP – Delta Smelt (Service File 1-1-93-F-32); Delta smelt.
- September 2, 1993–Los Vaqueros vernal pool shrimp conference opinion (Service File 1-1-93-C-68); vernal pool fairy shrimp, longhorn fairy shrimp, California linderella.
- September 3, 1993–Los Vaqueros Terrestrial (Service File 1-1-92-F-48); San Joaquin kit fox, bald eagle.
- September 9, 1993–Los Vaqueros Project (Service File 1-1-93-F-35); Delta smelt.

Regional Director

5

- February 4, 1994–1994 OCAP (Service File 1-1-94-F-2); Delta smelt.
- December 27, 1994–Interim Water Contract Renewal (Service File 1-1-94-F-69); San Joaquin kit fox, large-flowered fiddleneck, giant garter snake, vernal pool fairy shrimp, other species.
- February 23, 1995–Amendment of December 27, 1994 Interim Water Contract Renewal Opinion to include critical needs planning (Service File 1-1-95-F-39).
- March 6, 1995–Long-term OCAP (Service File 1-1-94-F-70); Delta smelt, Delta smelt critical habitat, Sacramento splittail [amended April 26, 1995 (Service File 1-1-95-F-804)].
- April 9, 1995–Striped Bass Management (Service File 1-1-95-F-58); Delta smelt (amended on May 30, 1996).
- August 7, 1995–Los Vaqueros Project adoption of September 2, 1993, conference opinion (Service File 1-1-95-F-117); vernal pool fairy shrimp and longhorn fairy shrimp.
- April 26, 1996–Temporary Barriers (Service File 1-1-96-F-53); Delta smelt and Delta smelt critical habitat.
- June 6, 1996–Los Vaqueros Project formal conference (Service File 1-1-95-F-134); California red-legged frog and Alameda Whipsnake (amended November 1, 1996).
- November 8, 1996–Los Vaqueros Project amendment and adoption of June 6, 1996, conference opinion for California red-legged frog and issuance of conference opinion for Alameda whipsnake (1-1-96-F-151).
- January 20, 1998–Interim Water Contract Renewal Opinion amendment (1-1-98-F-383); San Joaquin kit fox, large-flowered fiddleneck, giant garter snake, vernal pool fairy shrimp, other species.
- February 27, 1998–Re-initiation of Formal Endangered Species Consultation on the Supplemental Interim Renewal of Central Valley Project Water Contracts to include 14 Pronghorn Water Contracts (Service File 1-1-98-F-595); San Joaquin kit fox, blunt-nosed leopard lizard, Fresno kangaroo rat, and other species.
- March 19, 1998–Refuge Water Supply Program (Service File 1-1-98-F-61); giant garter snake.
- February 29, 2000–Interim Biological Opinion (Service File 1-1-F-0056); several species.
- March 24, 2000–California Toxics Rule (Service File 1-1-98-F-21); several species.
- November 14, 2000–Programmatic Biological Opinion and Essential Fish Habitat Conservation Recommendations for the CVPIA.

Regional Director

6

- November 21, 2000–Implementation of the CVPIA and Continued Operation and Maintenance of the CVP, Programmatic Consultation (Service File 1-1-98-F-0124).
 - September 27, 2001–Grasslands Bypass Project biological opinion.
 - December 14, 2001–Interim Renewal Contract Consultation 2002-2004, CVP, Supplemental Information.
 - April 11, 2003–Informal Section 7 Consultation on Multiple Categories of Temporary Water Service Actions for CVP Water Service Contractors Occurring Under the Authority of Reclamation, for Water Years 2002-2005; Two-Year Concurrence for Water Years 2003-2004 (Service File 1-1-03-F-1689).
 - February 27, 2004–Interim Water Contract Renewal Biological Opinion (Service File 1-1-04-F-0360); several species.
 - April 5, 2004. Reclamation requests initiation of formal consultation and transmits biological assessment for the execution of a long-term water service contract renewal between the United States and CCWD.
 - October 2004. Service requests an extension until December 17, 2004, to complete our final biological opinion (Service file no. 1-1-04-F-1504).
 - February 15, 2005. Reinitiation of Formal and Early Section 7 Endangered Species Consultation on the Coordinated Operations of the Central Valley Project and State Water Project and the Operational Criteria and Plan to Address Potential Critical Habitat Issues (Service File 1-1-05-F-0055).
 - February 18, 2005. Contra Costa Water District letter clarifying funding issues relative to the operations and maintenance of the habitat conservation plan areas
- Affected Species and Critical Habitat**
- Because biological opinion 1-1-99-F-0093 has already analyzed the effects of the annual delivery of 195 TAF of CVP water, the purposes of this reinitiation and amendment of formal consultation and conference of biological opinion 1-1-99-F-0093 is to: 1) meet Reclamations obligation under biological opinion 1-1-99-F-0093 to initiate consultation on contract renewals; 2) Amend biological opinion 1-1-99-F-0093 to address effects of the proposed action on the federally threatened California tiger salamander (*Ambystoma californiense*), valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*), pallid manzanita (*Arctostaphylos pallida*), and conference on the proposed critical habitats for the California tiger salamander and California red-legged frog; and 3) Amend biological opinion 1-1-99-F-0093 to authorize renewal of the long term water service contract for municipal and industrial water supply only for a period of 40 years. This document is in accordance with section 7 of the Endangered Species Act

of 1973, as amended (16 U.S.C. 1531 *et seq.*) (Act).

The Service hereby concurs with Reclamations determination that the execution of a long term water service contract between the United States and CCWD may affect but is not likely to adversely affect the riparian woodrat (*Neotoma fuscipes riparia*), riparian brush rabbit (*Sylvilagus bachmani riparius*), California brown pelican (*Pelecanus occidentalis californicus*), western snowy plover (*Charadrius alexandrinus nivosus*), bald eagle (*Haliaeetus leucocephalus*), Lange's metalmark butterfly (*Apodemia mormo langei*), callippe silverspot butterfly (*Speyeria callippe callippe*), California freshwater shrimp (*Syncaris pacifica*), delta green ground beetle (*Elaphrus viridis*), (large-flowered fiddleneck (*Amsinckia grandiflora*), Contra Costa wallflower (*Erysimum capitatum* ssp. *angustatum*), Santa Cruz tarplant (*Holocarpha macradenia*), and Colusa grass (*Neostaffia colusana*) as described in the biological assessment. The Service has determined that the proposed action is not likely to adversely affect the valley elderberry longhorn beetle (*Desmocerius californicus dimorphus*) and pallid manzanita (*Arctostaphylos pallida*) the CCWD service area is outside the species' known range.

The Service concurs with Reclamation's determination that the proposed action may affect, but is not likely to adversely affect, designated critical habitat for Antioch dunes evening-primrose and Contra Costa wallflower. Effects of the proposed action on designated critical habitat for delta smelt were addressed in the July 30, 2004 biological opinion on OCAP. Designated critical habitat for longhorn fairy shrimp, vernal pool tadpole shrimp, vernal pool fairy shrimp, Contra Costa goldfields, Colusa grass, delta green ground beetle, valley elderberry longhorn beetle, Santa Cruz tarplant and large-flowered fiddleneck does not occur within the action area of this consultation.

Contemporaneous Consultations

The SFWO is currently engaged in consultation with Reclamation on related actions that are not considered part of the Environmental Baseline because final biological opinions have not yet been issued for them. These other consultations include:

- 1) Operation and Maintenance of CVP Water Conveyance Facilities in the Jurisdiction of the South-Central California Area Office. The CVPIA programmatic biological opinion anticipated that it may be desirable to cover some operations and maintenance activities under long term contract renewal biological opinions (page 2-46). Because Reclamation aggregated information at different geographic scales and levels of specificity for long term contracts and facility operation and maintenance, the Service determined it was necessary to conduct separate but concurrent consultation on operation and maintenance to meet Reclamation's target dates for long term contract renewal. This consultation will analyze effects of operation of any CVP facilities associated with renewal of the CCWD long term water service contract other than those analyzed in the OCAP biological opinion.
- 2) Renewal of all other CVP long term water service contracts. In addition to CCWD, Reclamation intends to renew all other long term water service contracts throughout the CVP in 2005.

AMENDMENT TO THE BIOLOGICAL OPINION

Description of the Proposed Action

The following is hereby added to biological opinion 1-1-99-F-0093:

The federal action evaluated in this document is the renewal of the existing long-term water service and repayment contract for the delivery of water from the CVP to the CCWD for a period of 40 years for municipal and industrial uses (M&I) only; previous deliveries for irrigated agriculture will not be provided under the new contract. The contract amount remains unchanged at 195,000 afa.

Location

The CCWD CVP service area totals approximately 112,922 acres. The CCWD service area falls within central and eastern Contra Costa County and includes a very small portion of Alameda County (145 acres). Contra Costa County is the ninth most populous county in California, with a population of approximately 930,000 as of January 1, 2000. Eastern Contra Costa County includes the Cities of Bay Point, Pittsburg, Antioch, and much of the hilly terrain of the Diablo Range. Central Contra Costa County includes the Cities of Clayton, Clyde, Concord, Pacheco, Port Costa, Pleasant Hill, parts of Martinez, Walnut Creek and unincorporated areas of Contra Costa County. Interstate 680 provides a major north-south transportation and commercial corridor through the region, and State Highway 4 provides a major east-west transportation corridor through the region. The CCWD currently serves an estimated population of 450,000. Table 1 provides approximate irrigated acres and population for 1989 and 1995 and current water service contract amounts for the CCWD. Reclamation believes that for long-term water service contract renewal or replacement actions, the CCWD CVP water service area and the ESA action area are the same.

Table 1. Historical Irrigated Acreages and Population served by Central Valley Project Water in the Contra Costa Water District: Contract Amount: 195,000 acre-feet/year

Timeframe	Average Irrigated Acreage (acres)	Municipal & Industrial Population
1989	1,100	370,000
1995	700	414,000
2025 (projected)	--	568,000

Information from Water Needs Assessment (U.S. Bureau of Reclamation 2004; Volume II, Appendix D)

Contract Provisions

The proposed long-term water service contract will provide for the delivery of 195,000 afa of CVP water to CCWD for the purposes of M&I use only. Unlike the existing Amendatory Contract, the proposed long-term water service contract will not provide for the delivery of irrigation water. Irrigation deliveries under the existing contract were very small; therefore, for the purposes of the proposed long-term water service contract, CCWD will utilize non-project water supplies to satisfy their irrigation demands. The activity is ongoing and information developed thus far has been coordinated with the Service. Water deliveries will be made through existing CVP facilities. The project does not require the construction of any new facilities, the installation of any new structures, or the modification of existing facilities. However, a new alternative intake project is being planned in the Central Delta on Old River, with an associated pipeline connecting to Contra Costa Canal and Los Vaqueros Reservoir. This project is being planned and designed currently, and an EIS/EIR will be prepared and circulated for public and agency review and comment. As part of that review process, a Section 7 consultation will be conducted to evaluate the effects of the project on protected species. The water will be put to beneficial use within the authorized place of use for CVP water. The maximum contract quantities of 195,000 afa were analyzed in the Service's 2004 OCAP biological opinion (U.S. Fish and Wildlife Service 2004a) under Section 7 of the Act. Reclamation will retain the flexibility to reduce actual water deliveries as necessary for a variety of environmental needs. Reclamation is meeting existing CVP water allocations consistent with hydrological conditions and regulatory and environmental requirements.

The CVPIA states that the Secretary of the Interior (Secretary) shall, upon request, renew any existing long-term irrigation repayment or water service contracts for the delivery of CVP water for a 25-year period. Section 3404(c) of the CVPIA clearly indicates that 25 years will be the upper limit for long-term irrigation repayment and water service contracts within the CVP. However, Section 3404(c) did not amend the provisions of Section 9(c) of the Reclamation Project Act of 1939, and the Reclamation Project Act of June 21, 1963, which authorized renewal of M&I water contract terms for up to 40 years. These authorizations remain in place as guidance for establishing the terms of M&I contracts. Therefore, because the proposed long-term water service contract with the CCWD will provide for delivery of CVP water for M&I uses only, the term for the proposed contract is 40 years. The proposed long-term water contract would allow continued CVP water delivery to the CCWD for a 40-year period.

Water Needs Assessment

The water rights granted to the CVP by the State Water Resources Control Board require the federal government to determine that water is being used in a beneficial manner. A water needs assessment methodology was developed to ascertain if the CVP water is being used beneficially. The water needs assessment shows other sources of water available to CVP contractors and justifies the CVP contract amount.

The water needs assessment for the CCWD used the same multiple-step approach used throughout the CVP. First, the existing water demand was calculated based on historical water use. Agricultural use was determined by reviewing existing acreage, cropping patterns, crop water requirements, precipitation, and delivery efficiency. M&I water demand was evaluated

based on system efficiency, landscape acreage, landscape needs, and number of users. Second, the demand for future water use was determined based on changes in agricultural use, M&I expansion, and changes in efficiencies. Third, existing and future water supplies, including groundwater and other surface water supplies, were identified. The needs analysis included the identification of existing and future supplies of non-CVP water that might be available to supply the water use needs. The identification of alternative water sources assumed that supplemental water supplied by groundwater pumping would not exceed the safe yield of the aquifer. The analysis allowed for potential intra-regional transfers of water on an annual basis. Beneficial and efficient future water demands were also identified for the CCWD. The demands were compared to available non-CVP water supplies to determine the need for CVP water. If the need was less than the contract amount, the CVP water service contract amount could be reduced. Because the CVP was initially established as a supplemental water supply for areas with inadequate supplies, most contractors' needs were at least equal to the CVP water service contract and frequently exceeded the previous contract amount. Increased total contract amounts were not included in the needs assessment; therefore, the renewed CVP contract amount is limited by the existing contract quantity.

Table 2 shows the total amounts of CVP water delivered to the CCWD, the CCWD's total water supply including any transfers or exchanges into or out of the CCWD, the total water demands and the amount of the surplus or unmet demand. This information is provided for 1989, 1995, and 2025. Water supply, demand, and delivery information is based on a normal hydrologic year. The data provided in Table 2 are assumed to be representative of the last ten years.

Table 2. CCWD Water Needs Assessment (Supply Sources and Quantities) for 1989, 1995, and 2025 (in acre-feet, and based on a normal hydrologic year)

Year	Ref. Safe Deliv	Total Deliv/Max	Local	Recl. Local Source	Distrit	Private Supply	Total Ag Deliv (AF)	Cale Urban M&I Deliv (AF)	Total M&I Deliv (AF)
1989	123,657	133,224	8,000		960	2,040	144,224	144,224	0
1995	195,000	135,000	18,200	Mallard	960	2,040	156,200	153,000	3,200
2025 (proj)	195,000	195,000	8,200	East Contra Costa ID	960	2,040	206,200	207,200	1,000

Information from Water Needs Assessment (U.S. Bureau of Reclamation 2004; Volume II, Appendix D)

Groundwater resources in the CCWD service area do not supply significant amounts of water to meet or augment raw water demands (CCWD 2000 in Reclamation 2004). Of the three major groundwater sources – Ygnacio, Clayton, and the Pittsburg/Antioch areas, only the Clayton area produces appreciable amounts of groundwater, up to 3,000 afa. Existing CCWD wells in the vicinity of the Bollman Water Treatment Plant can provide approximately 1,000 to 1,500 afa but are limited by the threat of contamination from adjacent industrial areas and physical factors such

as air entrainment. Wells elsewhere in the CCWD service area can provide about 2,000 afd (CCWD 1998 in U.S. Bureau of Reclamation 2004).

Water Conservation

The CCWD has implemented a water conservation program with extensive public outreach to all water users. In addition to educational programs, CCWD also took measures to reduce its own consumption of water. The treated water distribution system is now continually surveyed for leaks and malfunctioning meters and there is a regular maintenance program for the Contra Costa Canal lining.

Action Area

The Action Area described in biological opinion 1-1-99-F-0093 remains unchanged.

Status of the Species and Critical Habitat

The following is hereby added to biological opinion 1-1-99-F-0093:

California Red-Legged Frog Proposed Critical Habitat

On March 13, 2001, the final rule determining critical habitat for red-legged frogs was published in the Federal Register (U.S. Fish and Wildlife Service 2001). This rule established 31 critical habitat units based on three primary constituent elements: (a) essential aquatic habitat; (b) associated uplands; and (c) dispersal habitat connecting essential aquatic habitat. In November 2002, the U.S. District Court for the District of Columbia vacated most of the 2001 designation and ordered the Service to publish a new critical habitat proposal. On April 13, 2004, the Service re-proposed 4.1 million acres in 28 California counties as critical habitat for the frog (U.S. Fish and Wildlife Service 2004d). This proposed rule basically re-proposes the same areas designated critical habitat in the 2001 final rule.

The Service is required to list the known primary constituent elements together with the critical habitat description. Such physical and biological features include, but are not limited to, space for individual and population growth and for normal behavior; food, water, air, light, minerals, or other nutritional or physiological requirements; cover or shelter; sites for breeding, reproduction, rearing (or development) of offspring; and habitats that are protected from disturbance or are representative of the historic geographical and ecological distributions of a species (U. S. Fish and Wildlife Service 2004d).

Due to the complex life history and dispersal capabilities of the California red-legged frog, and the dynamic nature of the environments in which they are found, the primary constituent elements described below are found throughout the watersheds that are proposed as critical habitat. Special management, such as habitat rehabilitation efforts (e.g., removal of nonnative predators), may be necessary in the area designated. The proposed critical habitat for the California red-legged frog provides for breeding and non-breeding habitats and for dispersal

between these habitats, as well as allowing for expansion of frog populations vital to the recovery of the subspecies. The proposed critical habitat includes: (a) essential aquatic habitat; (b) associated uplands; and (c) dispersal habitat connecting essential aquatic habitat.

Aquatic Habitat. Aquatic habitat is essential for providing space, food, and cover, necessary to sustain all life stages of red-legged frogs. It consists of virtually all low-gradient fresh water bodies, including natural and man-made (e.g., stock) ponds, backwaters within streams and creeks, marshes, lagoons, and dune ponds, except deep lacustrine water habitat (e.g., deep lakes and reservoirs 50 acres or larger in size) inhabited by nonnative predators. The subspecies requires a permanent water source to ensure that aquatic habitat is available year-round. Permanent water sources can include, but are not limited to, ponds, perennial creeks, permanent plunge pools within intermittent creeks, seeps, and springs. Aquatic habitat used for breeding usually has a minimum deep water depth of 20 inches, and maintains water during the entire tadpole rearing season (at least March through July). During periods of drought, or less-than-average rainfall, these breeding sites may not hold water long enough for individuals to complete metamorphosis, but because they support breeding in wetter years these sites would still be considered essential breeding habitat. Ponds that support a small population of red-legged frogs, but are not surrounded by suitable upland habitat, or are cut off from other breeding ponds or permanent water sources by impassable dispersal barriers, do not have the primary constituent elements for proposed California red-legged frog critical habitat.

To be a primary constituent element for California red-legged frog proposed critical habitat, the aquatic components within the designated boundaries must include two or more breeding sites (as defined above) located within 1.25 miles of each other; at least one of the breeding sites must also be a permanent water source; or, the aquatic component can consist of two or more seasonal breeding sites with a permanent non-breeding water source located within 1.25 miles of each breeding site. California red-legged frogs have been documented to travel 2.25 miles in a virtual straight line migration from non-breeding to breeding habitats (U.S. Fish and Wildlife Service 2001). In addition, breeding sites must be connected by dispersal habitat connecting essential aquatic habitat, described below.

Upland Habitat Associated with Aquatic Habitat. Associated upland and riparian habitat is essential to maintain California red-legged frog populations associated with essential aquatic habitat. The associated uplands and riparian habitat provide food and shelter sites for California red-legged frogs, and assist in maintaining the integrity of aquatic sites by protecting them from disturbance and supporting the normal functions of the aquatic habitat. Key conditions include the timing, duration, and extent of water moving within the system, filtering capacity, and maintaining the habitat to favor red-legged frogs and discourage the colonization of nonnative species such as bullfrogs. Essential upland habitat consists of all upland areas within 300 feet, or no further than the watershed boundary, of the edge of the ordinary high-water mark of essential aquatic habitat (U.S. Fish and Wildlife Service 2001).

Dispersal Habitat Connecting Essential Aquatic Habitat. Essential dispersal habitat provides connectivity among red-legged frog breeding habitat (and associated upland) patches. While

Frogs can pass many obstacles, and do not require a particular type of habitat for dispersal, the habitat connecting essential breeding locations and other aquatic habitat must be free of barriers (e.g., a physical or biological feature that prevents frogs from dispersing beyond the feature) and at least 300 feet wide. Essential dispersal habitat consists of all upland and wetland habitat free of barriers that connects two or more patches of essential breeding habitat within 1.25 miles of one another. Dispersal barriers include heavily traveled roads (an average of 30 cars per hour from 10:00 p.m. to 4:00 a.m.) that possess no bridges or culverts; moderate to high density urban or industrial developments; and large reservoirs more than 50 acres in size. Agricultural lands such as row crops, orchards, vineyards, and pastures do not constitute barriers to red-legged frog dispersal.

California Tiger Salamander

Status. The California tiger salamander was federally listed as threatened throughout its range on August 4, 2004 (U.S. Fish and Wildlife Service 2004b). Detailed information about the tiger salamander can be obtained in this document. In the final listing rule we also finalized a special rule exempting routine ranching activities from the definition of take in section 9 of the Endangered Species Act and Service regulations at 50 CFR 17.31. The special rule was finalized in accordance with section 4(d) of the Endangered Species Act. Critical habitat was proposed for the Santa Barbara population of the California tiger salamander on January 22, 2004 (69 FR 3064), and for the Central population of the California tiger salamander on August 10, 2004 (U.S. Fish and Wildlife Service 2004c). Although no proposed critical habitat is affected by this action, the proposed rules contain additional information on the biology, ecology, and conservation needs of the California tiger salamanders that are relevant to this consultation.

Tiger salamanders continue to be threatened by human activities. Current factors associated with declining populations of the tiger salamander include continued destruction, degradation, and fragmentation of habitat due to urbanization, and conversion to intensive agriculture. Other factors that contribute to the decline of the species include hybridization with nonnative tiger salamanders and nonnative predators. Isolation and fragmentation of habitats within many watersheds precludes dispersal between sub-populations and jeopardized the viability of metapopulations (broadly defined as multiple subpopulations that occasionally exchange individuals through dispersal, and are capable of colonizing or "rescuing" extinct habitat patches).

California tiger salamander occurs in the Coast Ranges in southern Sonoma County, San Mateo County south to San Luis Obispo County, and northwestern Santa Barbara County. In the Central Valley and Sierra Nevada foothills the species is patchily distributed from northern Yolo County southward to northwestern Ken County and northern Tulare and Kings County.

Species Description and Life History. The tiger salamander is a large, stocky, terrestrial salamander with a broad, rounded snout. Adults may reach a total length of 207 mm (8.2 in). Tiger salamanders exhibit sexual dimorphism; males tend to be larger than females. Coloration of the tiger salamander is white or yellowish markings against black. As adults, tiger

salamanders tend to have the creamy yellow to white spotting on the sides with much less on the top, whereas other tiger salamanders have brighter yellow spotting with more on the top. The eggs of tiger salamander are usually laid singly or in small clusters of two to four, whereas the eastern tiger salamander lays eggs in larger globular or oblong masses consisting of from 23 to 110 eggs (Bishop 1943; Stebbins 1962).

Tiger salamanders require both wetland and adjacent upland habitat to complete their life cycle (Shaffer *et al.* 1993). During the rainy season tiger salamanders breed in wetlands, where their aquatic larvae complete their development and metamorphosis. At the onset of the dry season metamorphosed juveniles and adults retreat to burrows in nearby uplands and enter estivation (a state of dormancy or inactivity in response to hot, dry weather). Each year breeding salamanders migrate back and forth between their upland estivation habitat and wetland breeding habitat.

Vernal pools are important California tiger salamander breeding habitat in the Central Valley, Southern San Joaquin Valley, and Sonoma County. Stock ponds have become important breeding habitat in the Bay Area, Coast Ranges, and Santa Barbara regions, largely due to destruction of vernal pool habitat in these regions.

Tiger salamanders spend much of their adult lives in small mammal burrows, particularly those of ground squirrels and pocket gophers (Loredo and Van Vuren 1996; Trenham 1998a). During summer estivation, tiger salamanders apparently eat very little, but they may emerge from estivation to feed during cool, moist nights (Shaffer *et al.* 1993). Between November and January, the first heavy fall and winter rains prompt adults to emerge from the burrows at night, feed, and migrate to the breeding ponds (Storer 1925; Stebbins 1985; Shaffer *et al.* 1993; Loredo and Van Vuren 1996; Trenham 1998b). Migration distances between estivation and breeding sites vary widely, with most observations ranging from 100 to 1600 m (330 to 5280 ft.) (Austin and Shaffer 1992; Hunt 1998; Trenham 1998a).

Factors Affecting Population Size. Populations of tiger salamanders likely fluctuate from year to year. When conditions are favorable, the tiger salamanders may experience extremely high rates of reproduction and thus produce large numbers of dispersing young with a concomitant increase in the number of occupied sites. In contrast, tiger salamander populations may temporarily decrease in an area when conditions are stressful (e.g. drought). Nonnative predators such as bullfrogs, mosquitofish, sunfish, catfish, and bluegill may affect local population size by diminishing or eliminating California tiger salamander larvae in individual ponds. Control of burrowing mammals also may affect local population size of California tiger salamander by destroying estivation habitat and possibly estivating salamanders. Lifetime reproductive success for California and other tiger salamanders is low; the mechanisms for recruitment depend on numerous factors, including migration, terrestrial survival, and population turnover, whose interaction is not well understood (Trenham 1998b). It is thought that reproductive output in most years is not sufficient to maintain populations, which suggests that the species requires occasional large breeding events to prevent extirpation (Trenham *et al.* 2000). With such low recruitment, isolated populations are susceptible to unusual, randomly occurring natural events as well as from human-caused factors that reduce breeding success and individual survival. Factors that repeatedly lower breeding success in isolated vernal pools or ponds can quickly lead to

localized extirpation.

Historical Distribution. Historically, the tiger salamander inhabited low elevation grassland and oak savanna plant communities of the Central Valley, adjacent foothills, and the inner Coast Ranges in California (Storer 1925; Shaffer *et al.* 1993) from sea level up to about 460 m (1,500 feet). Along the Coast Ranges of California, the species occurred from the Santa Rosa area of Sonoma County south to the vicinity of Buellton in Santa Barbara County. In the Central Valley and surrounding foothills, the species occurred from northern Yolo County (Dunnigan) and southern Butte County southward to northwestern Kern County and northern Tulare County.

Reasons for Decline and Threats to Survival. A primary cause of the decline of the California tiger salamander is the conversion of habitat for urban and agricultural activities (D. Wake *in litt.* 1992; T. Jones *in litt.* 1993; Shaffer *et al.* 1993, U.S. Fish and Wildlife Service 2004b, CNDDB 2004). Some of the largest remaining subpopulations are in areas severely threatened by new urban development, including the Livermore Valley, Santa Clara Valley, and Fresno areas. In addition to direct loss of habitat, the widespread conversion of land to residential and agricultural uses has fragmented habitat throughout the range of the tiger salamander and has isolated remaining populations (Shaffer *et al.* 1993). Urban effects include housing, commercial, and industrial developments; road construction and widening; golf course construction and maintenance; trash dumping, landfill operation and expansion; and operation of gravel mines and quarries.

Agricultural effects include disking and deep-ripping; and cultivation, planting and maintenance of row crops, orchards, and vineyards. Historically, approximately 6.31 million ha (15.59 million ac) of valley and coastal grasslands blue oak/fothill pine, valley oak, or mixed hardwood lands (Kuchler 1988), existed. Urbanization and intensive agriculture have eliminated virtually all valley grassland and oak savanna habitat from the Central Valley floor. Currently there are about 1.1 million ac where the tiger salamander potentially is still extant.

The relative loss of habitat has been even more extreme with respect to vernal pools, the historic breeding habitat of the tiger salamander. Remaining vernal pool complexes are now fragmented and reduced in area. Where vernal pools remain, they are often disturbed and degraded by drainage modification, overgrazing, ORV use, non-native plant invasion, trash dumping, road construction, and urban development (Jones and Stokes Associates 1987, U.S. Fish and Wildlife Service 1994c, Keeler-Wolf *et al.* 1998).

While the California tiger salamander does breed successfully in stockpounds, they often are poorer habitat for tiger salamanders than natural vernal pools. Hydroperiods may be so short that larvae cannot metamorphose, or so long that predatory fish and bullfrogs (*Rana catesbeiana*) can colonize the pond (Shaffer *et al.* 1993, Seymour and Westphal 1994). Extirpation of a tiger salamander occurrence is likely if fish are introduced (Shaffer *et al.* 1993, Seymour and Westphal 1994).

A number of nonnative species have adversely affected the California tiger salamander through predation and competition. A strong negative correlation exists between bullfrog presence and

tiger salamander presence (Shaffer *et al.* 1993, Seymour and Westphal 1994). Morey and Guinn (1992) documented a shift in amphibian community composition at a vernal pool complex, with salamanders becoming proportionally less abundant as bullfrogs increased in number. Western mosquitofish (*Gambusia affinis*) have also likely adversely affected tiger salamanders via predation and competition. Loredo-Prendeville *et al.* (1994) failed to find any tiger salamanders inhabiting ponds containing mosquitofish. About 50 local mosquito abatement districts plant the fish throughout the state (Boyce *in litt.* 1994). Wild pigs (*Sus scrofa*) have had pronounced negative ecological effects on tiger salamanders (Walshman *et al.* 1999). Detrimental effects of wild pigs include both predation and habitat modification.

A number of other non-native species have either been directly implicated in predation of tiger salamander or appear to have the potential for such. Introductions of largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), catfish (*Ictalurus* spp.), and fathead minnows (*Pimephales promelas*) likely eliminated tiger salamanders from several breeding sites in Santa Barbara County (U.S. Fish and Wildlife Service 2000b). Non-native sunfish, catfish, and bullheads (*Ameiurus* spp.) have been and still are widely planted in ponds in California for sportfishing. Crayfish (*Pacifastacus*, *Orconectes*, and *Procambarus* spp.) are also known to prey on California newt eggs and larvae, despite toxins they produce (Gamradt and Kats 1996).

Like most amphibians, tiger salamanders inhabit both aquatic and terrestrial habitats at different stages in their life cycle. Therefore, they are exposed to both aquatic and terrestrial pollutants due to their highly permeable skin (Blaustein and Wake 1990). Oil and other contaminants from road runoff have been detected in ponds and linked to die-offs of and deformities in tiger salamanders and spadefoot toads (*Scaphiopus hammondi*) as well as die-offs of invertebrates that form most of both species' prey base (S. Sweet, *in litt.*, 1993).

During 2001, the 23 counties where tiger salamanders occur used over 105 million pounds of pesticides (California Department of Pesticide Regulation Internet website, December 2002), some of which are extremely toxic to aquatic organisms, including amphibians and the organisms on which they prey. Some of these pesticides, such as chlorpyrifos, malathion, and endosulfan are cholinesterase inhibitors. Reduced cholinesterase activity has been linked to uncoordinated swimming, increased vulnerability to predation, depressed growth, and increased mortality in tadpoles (Berrill *et al.* 1998, Bridges 1997, de Lamas *et al.* 1985, Rosenbaum *et al.* 1988, Sparling *et al.* 2001). Even when toxic or detectable amounts of pesticides are not found in breeding ponds or groundwater, salamanders may still be affected, particularly by chemicals applied during the migration and dispersal seasons. Sparling *et al.* (2001) examined pesticide usage and amphibian (*Rana* and *Bufo* spp.) population declines in California and provided evidence that pesticides are instrumental in declines of these species.

Widespread control of ground squirrels and pocket gophers may pose a significant threat to the tiger salamander. Ground squirrel control is done by trapping, shooting, fumigation, toxic (including anticoagulant) baits, and habitat modification, including deep-ripping of burrow areas (UCIPM Internet website, January 2003). Ground squirrel and pocket gopher control may have the indirect effect of reducing the number of upland burrows available to specific tiger salamander subpopulations (Loredo-Prendeville *et al.* 1994).

Light to moderate livestock (cattle, sheep, and horses) grazing is generally thought to be compatible with continued successful use of rangelands by the tiger salamander, provided the grazed areas do not also have intensive burrowing rodent control efforts (T. Jones, *in litt.* 1993, Shaffer *et al.* 1993, S. Sweet, pers. comm. 1998, Shaffer and Trenham, pers. comm., 2003). By maintaining shorter vegetation, grazing may make areas more suitable for ground squirrels whose burrows are essential to tiger salamanders.

Conservation Needs. Conservation of the California tiger salamander requires a five-pronged approach: (1) maintaining the current genetic structure across the species' range; (2) maintaining the current geographic, elevational, and ecological distribution; (3) protecting the hydrology and water quality of breeding pools and ponds; (4) retaining or providing for connectivity between breeding locations for genetic exchange and recolonization; and (5) protecting sufficient barrier-free upland habitat around each breeding location to allow for sufficient survival and recruitment to maintain a breeding population over the long term. Specific actions that help meet these goals include, but are not limited to, protection, restoration, and management of large blocks of contiguous aquatic and terrestrial habitat; management of stock ponds to eliminate or reduce populations of nonnative predators; elimination of nonnative tiger salamanders and their hybrids; and reduced exposure to contaminants, particularly in the vulnerable larval stages.

California Tiger Salamander Proposed Critical Habitat

Critical habitat was proposed for the central population of the California tiger salamander on August 10, 2004 (U.S. Fish and Wildlife Service 2004c). Final critical habitat was designated for the California tiger salamander in Santa Barbara County on November 24, 2004 (69 FR 68568). The Service divided the current range of the Central population into four regions: (1) Central Valley; (2) Southern San Joaquin Valley; (3) East Bay; and (4) Central Coast, which represent the unique genetic structure of the subspecies. The action area is located in the East Bay region.

The Service determined that conserving the California tiger salamander over the long-term requires a five-pronged approach: (1) Maintaining the current genetic structure across the species range; (2) maintaining the current geographical, elevational, and ecological distribution; (3) protecting the hydrology and water quality of breeding pools and ponds; (4) retaining or providing for connectivity between locations for genetic exchange and recolonization; (5) protecting sufficient barrier-free upland habitat around each breeding location to allow for sufficient survival and recruitment to maintain a breeding population over the long-term (U.S. Fish and Wildlife Service 2004).

The Service believes that areas proposed for critical habitat may require certain management considerations or protections due to the following threats: (1) Activities that introduce or promote the occurrence of bullfrogs and fish; (2) Activities that could disturb aquatic habitats during the breeding season; (3) Activities that impair the water quality of aquatic breeding habitats; (4) Activities that would reduce small mammal populations to the point that there is insufficient underground Central population refugia used for foraging, protection from predators,

and shelter from the elements; (5) Activities that create barriers impassible for salamanders or road crossings that increase mortality in upland habitat between extant occurrences in breeding habitat; (6) Activities on adjacent uplands that disrupt vernal pool complexes' ability to support California tiger salamander breeding function; (7) Activities that introduce non-native tiger salamanders in areas where the California tiger salamander is threatened with hybridization (U.S. Fish and Wildlife Service 2004c).

In determining which areas to designate as critical habitat, the Service considers those physical and biological features (primary constituent elements) that are essential to the conservation of the species, and that may require special management considerations and protection (50 CFR § 424.14). The Service lists the known primary constituent elements together with the proposed critical habitat description. Such physical and biological features include, but are not limited to, space for individual and population growth and for normal behavior; food, water, air, light, minerals, or other nutritional or physiological requirements; cover or shelter; sites for breeding, reproduction, rearing (or development) of offspring; and habitats that are protected from disturbance or are representative of the historic geographical and ecological distributions of a species.

The primary constituent elements for the California tiger salamander are aquatic and upland areas, including vernal pool complexes, where suitable breeding and non-breeding habitats are interspersed throughout the landscape, and are interconnected by continuous dispersal habitat. All areas proposed as critical habitat for the central population contain one or more of the primary constituent elements (U.S. Fish and Wildlife Service 2004c).

Breeding Habitat. Standing bodies of fresh water, including natural and man-made (e.g. stock) ponds, vernal pools, and other ephemeral or permanent water bodies that typically become inundated during winter rains and hold water for a sufficient length of time necessary for the species to complete its life cycle (U.S. Fish and Wildlife Service 2004c).

Breeding California tiger salamander are found in vernal pools, vernal pool complexes, and seasonal ponds in associated annual grasslands, oak savannah, and coastal bay scrub plant communities of the Bay Area (Santa Clara Valley), Central Coast, Central Valley, and Southern San Joaquin Valley. The California tiger salamander also have adapted to using artificial water bodies, such as stock ponds during their aquatic phase. However, stockponds are often not optimum breeding habitat because the hydroperiod is so short there is not sufficient time for larvae to metamorphose, or it is so long that predatory fish and bullfrogs can colonize the pond. Permanent wetlands can support breeding California tiger salamander if fish are not present, but extirpation of the salamander is likely to occur if fish are introduced. Periodic maintenance to remove silt from stockponds and other artificial waterbodies may also cause a temporary loss of functioning aquatic habitat. Regardless of vernal pool, pond, or seasonal wetland type, successful breeding ponds for California tiger salamander need to be inundated for a minimum of 21 weeks to allow for successful metamorphosis (2004c).

Non-Breeding Habitat. California tiger salamanders spend the majority of their lives in barrier-free upland habitats adjacent to breeding ponds. Within these upland habitats, adult California

tiger salamander spend part of their lives in the underground burrows of mammals, especially the burrows of the California ground squirrel and valley pocket gopher, with depths ranging from 20 centimeters to 1 meter beneath the ground surface. Small mammals are essential in creating the underground habitat that adult California tiger salamander depend on for food, shelter, and protection from the elements and from predation. Although California tiger salamander are members of a family of burrowing tiger salamanders, California tiger salamander are not known to create their own burrows in the wild and require small mammal burrows for survival. The upland component of the Central population habitat typically consists of vernal pool grassland or grassland savannah with scattered oak trees. However, some occupied California tiger salamander breeding ponds exist within mixed grassland and woodland habitats, in woodlands, scrub, or chaparral habitats (U.S. Fish and Wildlife Service 2004c).

Dispersal and Migration. Movements made by California tiger salamander can be grouped into two main categories: (1) Breeding migration, and (2) interpond dispersal. Breeding migration is the movement of salamanders to and from a pond from the surrounding upland habitat. After metamorphosis, juveniles move away from breeding ponds into the surrounding uplands, where they live continuously for several years (on average, four years). Upon reaching sexual maturity, most individuals return to their natal (birth) pond to breed, while 20 percent disperse to other ponds (U.S. Fish and Wildlife Service 2004c).

Essential dispersal habitats generally consist of upland areas adjacent to essential aquatic habitats which are not isolated from other essential aquatic habitats by barriers that California tiger salamander cannot cross. Essential dispersal habitats provide connectivity among California tiger salamander suitable aquatic and upland habitats. While California tiger salamander can bypass many obstacles, and do not require a particular type of habitat for dispersal, the habitats connecting essential aquatic and upland habitats need to be free of barriers (e.g. a physical or biological feature that prevents salamanders from dispersing beyond the feature) to function effectively (U.S. Fish and Wildlife Service 2004c).

The Service proposed critical habitat that allowed for dispersal between extant occurrences within 0.7 mile of each other. This distance was selected because it provides for 99 percent of the chances that individual salamanders can move and breed between extant occurrences, and, thereby, provides for genetic exchange between individual within the region (U.S. Fish and Wildlife Service 2004c).

Environmental Baseline

The following is hereby added to biological opinion 1-1-99-F-0093:

California Red-Legged Frog Proposed Critical Habitat

The project occurs within the East Bay-Diablo Range critical habitat unit (Unit 15). Unit 15 consists of watersheds within Contra Costa, Alameda, San Joaquin, Santa Clara, Stanislaus, San Benito, Merced, and Fresno Counties. The unit encompasses approximately 1,053,850 ac. of which 87 percent is privately owned; the remaining 13 percent is managed, in part, by East Bay

Regional Park District (EBRPD), East Bay Municipal Utilities District, CCWD, Reclamation, U.S. Department of Energy, California Department of Parks and Recreation, San Francisco Public Utilities Commission, California Department of Fish and Game, Santa Clara Valley Water District, and California Department of Water Resources.

Unit 15 is occupied by several large core subpopulations, including the population within CCWD and EBRPD lands, and essential aquatic habitat, associated uplands, and dispersal habitat connecting essential aquatic habitat is located throughout the unit. Unit 15 is an area in which existing California red-legged frog populations appear to be stable, in which they have been documented to show reproductive success over an extended period of time, and, as a result, likely can provide colonizers to nearby areas. The unit also represents an ecologically significant portion of the current range.

Because watershed boundaries were used to delimit critical habitat units in the current proposal, essential aquatic habitat, associated uplands, and essential dispersal habitat has not been widely mapped in the unit, the Service can not accurately estimate the area within the unit that supports primary constituent elements. However, due to the presence of busy roads and developed areas as well as substantial areas without permanent water, we anticipate that the effective area of Unit 15 is considerably less than 1.05 million acres. Unit 15 has been affected by activities that destroy essential aquatic and upland habitats, and dispersal habitats providing connectivity between subpopulations. Degradation and loss of these habitats have occurred through urbanization, mining, inappropriate management of grazing, recreation, invasion of nonnative plants, impoundments, water diversions, degraded water quality, and introduced predators.

California Tiger Salamander

Suitable habitat in the CCWD service area includes pools, ponds, stock ponds, drainage ponds, and natural wetlands in grassland and scrub communities. There are 146 known occurrences within the action area, in the following USGS quadrangles: Antioch North, Honker Bay, Clayton, Walnut Creek, Antioch South, Tassajara, Brentwood, Byron Hot Springs, Altamont, Livermore, and Diablo (CNDDB 2003). The species occurs throughout the CCWD service area; known occurrences are concentrated around the Contra Costa County/Alameda County line and the Los Vaqueros Reservoir, near the Keller Canyon Landfill, and along Marsh Creek Road, south of Antioch (CNDDB 2003).

California Tiger Salamander Proposed Critical Habitat

The CCWD CVP service area includes the following proposed critical habitat units:

Unit 14, Mulligan Hill Unit, Contra Costa County (5,895 ac)

This proposed unit represents the western portion of the Central Valley region and the Livermore vernal pool region in Contra Costa County. This proposed unit is bordered on the north by State Route 4, Concord on the west, Kirker Pass Road to the south, the City of Pittsburg to the east. The Department of Defense, Concord Naval Weapons Station, owns part of this proposed unit,

and the other part is privately owned. This unit represents the western portion of the Central Valley region of the California tiger salamander in terms of genetic structure and the Livermore vernal pool region in Contra Costa County, which is essential for maintaining the geographic and ecological distribution of the species.

Unit 15, Deer Valley Unit, Contra Costa County (7,353 ac)

This proposed unit contains ten extant occurrences of the CTS and represents the southwestern part of Central Valley region in terms of genetic structure and the Livermore vernal pool region in Contra Costa County. It is roughly bounded by Mount Diablo to the west, Antioch to the north, Deer Valley to the south, and Lone Tree Valley to the east. Land ownership is held in a combination of East Bay Regional Park System and private.

Unit 16, Marsh Creek Unit, Contra Costa County (13,502 ac)

This proposed unit contains 25 extant occurrences of the CTS and represents the southwestern portion of the Central Valley region in the Livermore vernal pool region within Contra Costa County. This proposed unit is roughly bounded by Curry Canyon on the west, Deer Valley on the north, Round Valley on the south, and Marsh Creek Reservoir on the east. Land ownership is mostly private but includes a small amount of State land.

Unit 17, Bethany Reservoir Unit, Alameda and Contra Costa Counties (27,932 ac)

This proposed unit contains 50 extant occurrences of the CTS and represents the southwestern portion of the Central Valley region in the Livermore vernal pool region within Contra Costa County. It contains the highest density of CTS extant occurrences among all proposed units and represents a significant portion of the species' habitat and range. This unit is generally bounded by Interstate Freeway 580 on the south, Clifton Court Forebay on the east, the City of Bryon on the north, and Brushy Peak on the west. Land ownership is mostly private, with some State lands as well.

California tiger salamander critical habitat has experienced losses, fragmentation, and degradation and continues to be threatened by urban development, low density development, and conversions to agriculture. Although about 20 percent of occupied habitat is protected to some degree, the species is not protected from habitat losses and fragmentation from many other activities. Destruction, modification, and curtailment of California tiger salamander habitat is caused by such activities as; building and maintenance of housing, commercial and industrial developments, construction and widening of roads and highways, golf course construction and maintenance, landfill operation and expansion, operations of gravel mines and quarries, dam building and inundation of habitat by reservoirs, and other infrastructure activities that support urban areas. Agricultural impacts include conversion of native habitat by discing and deep ripping, planting and cultivation, irrigation, and maintenance of row crops, orchards, and vineyards. These activities threaten both breeding and upland habitats of the species (U.S. Fish and Wildlife Service 2004c).

HCP Development

[Insert discussion of current status of HCP and timeline for completion, area covered, etc.]

Effects of the Proposed Action

This document does not rely on the regulatory definition of "destruction or adverse modification" of critical habitat at 50 CFR 402.02. Instead, we have relied upon the statute and the August 6, 2004, Ninth Circuit Court of Appeals decision in *Gifford Pinchot Task Force v. U.S. Fish and Wildlife Service* (No. 03-35279) to complete the following analysis with respect to critical habitat.

Effects associated with use and application of CVP water supplies are beyond the control and authority of the lead Federal agency and the project applicant and will generally occur gradually throughout the 40-year term of the water service contracts, at a rate determined by economic and other factors, and to an extent and magnitude established in local land use planning documents. These effects are subject to the control and authority of local land use jurisdictions which can develop land use policies and participate in development of conservation strategies that are compatible with the conservation of listed species. Ultimately, the magnitude and extent of these effects will be dictated by the intersection of local land use policies and local social, political, and economic forces that are beyond the control of all parties to this consultation. We have based our analysis on information about local growth projected by CCWD in their water needs assessment, digital planned land use information from General Plans available in the public domain, and information being used in the development of the East Contra Costa HCP.

General Growth-Related Effects Common to All Species and Critical Habitat

Potential effects related to growth include direct habitat loss resulting from construction of the aforementioned types of development, as well as fragmentation and degradation of important habitats. Following is a description of the effects of habitat conversion and fragmentation common to all species critical habitat addressed in this biological opinion.

The most substantial consequences of development include habitat conversion and habitat fragmentation. Habitat conversion, aside from permanently destroying habitat, also can fragment remaining habitat and break habitat connectivity needed to allow a species to disperse throughout its range. Dispersal serves several different functions in population stability over time. It allows for gene flow and it provides for population expansion, colonization or re-occupation of habitat, and juvenile migration. These functions of dispersal habitat are important to maintain stable populations within available habitat through a species' range as local populations fluctuate over time. Loss of connecting habitat that reduces gene flow and population interchange may reduce the likelihood of survival and recovery of listed species by isolating populations within small habitat patches that are at increased risk of extirpation from stochastic events, inbreeding depression, or other factors. Habitat conversions that fragment and reduce the connectivity between remaining pieces of habitat are considered likely to have such effects on all listed species addressed in this consultation.

Habitat conversion and fragmentation affect listed species by gradually converting useful habitats to non-habitat or degraded habitat, and by fragmenting remaining habitat into smaller, unconnected patches that increase "edge" effects. These activities result in death of listed species or impairment of essential behaviors in many ways, including (a) through starvation, by destroying prey base and other food sources; (b) displacing animals and forcing movement to adjacent areas of non-habitat, increasing exposure to predators or other sources of mortality, such as roadways, dogs, cats, or forcing animals into adjacent habitat in which they must compete with resident individuals; (c) eliminating breeding and rearing habitat (burrows, trees, pools, etc.); (d) truncating hydrologic connections within seasonal wetland complexes that changes hydroperiods to regimes unsuitable for listed species that reproduce in seasonal wetlands, or by making hydroperiods more suitable for predators of listed species such as bullfrogs; (e) increasing exposure to oil, pesticides, and other toxic substances associated with urban environments; and (f) by increasing exposure to stressors such as noise, light, human presence, off-road vehicles, and garbage dumping associated with urban environments. The significance of these effects on survival and recovery of species addressed in this consultation, both within the action area and throughout their respective ranges, underscores the importance of continued implementation of conservation measures proposed by CCWD.

The development effects described above are the most serious when conservation is implemented in piecemeal fashion as part of the project-by-project review and approval process typical within jurisdictions in the action area. Federally listed species exist within the context of their ecosystem, the assemblage of species and their interactions within their associated physical environment. A primary purpose of the Endangered Species Act is "to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved". Ecosystems that support listed species, at least those addressed in this biological opinion, do not normally neatly correspond with, or conveniently fit within, the spatial scale of a single development. The functions of ecosystems, and thus conservation of listed species, are best addressed at larger spatial scales that vary depending on the biology of the species. When conservation of listed species is attempted one project at a time, the effects described above generally result in a slow decline in the status of the species, rather than improvement and progression to recovery. It is therefore our view that land use planning tools and processes that seek to achieve conservation at larger spatial scales that allow for ecosystem functions are more likely to meet the conservation needs of listed species than is the typical system of approving development proposals one at a time. Short of increasing the spatial scale at which development is planned and integrating listed species conservation into that planning, such as would occur with an HCP or other regional planning process, interaction with the Service at the very earliest stages of planning, and integration of listed species needs into project planning at the very earliest stages, also increases the likelihood of meeting the conservation needs of listed species.

The conservation measures of the April 27, 2000 biological opinion are appropriate tools within the authority of CCWD to ensure that the conservation of listed species is considered at early stages of the planning process. It is our view that implementation of these measures can substantially influence the effects of future development in ways that reduce the severity of adverse effects described above. It is more likely that development will be designed to reduce

fragmentation and more effectively accommodate conservation objectives such as providing connectivity between conserved lands, and protecting areas with high quality habitat, high restoration potential, unique species assemblages, and the like, if these considerations are factored into land use planning at early stages, or addressed directly through regional conservation planning in the form of an HCP. At a minimum, implementation of such measures increases the likelihood that growth and development over the long term will not preclude conservation opportunities, but they also can promote conservation of listed species and their habitats at the local level by increasing awareness of local agency staff and complementing existing local land use policies. The adverse effects described above do not occur immediately, or all at once. The commitments set forth in the biological opinion are effective conservation tools because they: (1) can be employed by local agencies to conduct their own activities in ways that are compatible with the conservation needs of listed species; (2) establish processes to integrate consideration of the conservation needs of listed species into the routine activities of local agencies; (3) encourage regional conservation approaches by local jurisdictions which, over the long term, has both ecological and economic benefits over conservation implemented one project at a time; and (4) ensure that other potentially growth inducing infrastructure projects do not make irreversible and irretrievable commitments that may preclude future conservation options.

California Red-legged Frog Proposed Critical Habitat

The indirect effects of the action, as described above, are likely to destroy, degrade, or fragment essential aquatic habitat, associated uplands, and dispersal habitat of the California red-legged frog. The development that causes these effects will occur incrementally throughout the 40-year time period of the water service contract in both space and time. These effects will be permanent in duration and are likely to affect a substantial portion of the area within Unit 15 within CCWD. However, with implementation of strategically situated conservation of California red-legged frog habitat concurrent with development through implementation of an interim conservation strategy or an ESA section 10(a)(1)(B) permit, we anticipate that the ability of the primary constituent elements to provide breeding, feeding, sheltering, and dispersal functions will be reduced in some areas but strengthened in other areas as other areas within Unit 15 possessing primary constituent elements are protected and managed to conserve California red-legged frogs. If implementation of conservation measures that remove threats and provide special management for California red-legged frog habitat concurrent with development occurs within the timeframes given in the **Description of the Proposed Action**, we anticipate that Unit 15 will maintain its conservation role of supporting stable, reproductively successful populations in the East Bay region.

California Tiger Salamander

Residential and commercial development, including buildings, transportation networks, and infrastructure could affect California tiger salamanders by earth moving activities, infrastructure improvements, building construction, landscaping, and other construction activities, which could eliminate upland aestivation habitat available to California tiger salamanders on the development sites. Individual California tiger salamanders aestivating on the development sites could be

crushed by construction activities that collapse their burrows or destroy soil desiccation cracks. Individual California tiger salamanders disturbed by construction activities could attempt overland movements in an attempt to find alternative aestivation habitat. These individuals could be harassed, injured and killed by pedestrians, vehicles, and urban adapted predators during overland movements at the development sites, or during attempts to find more suitable habitats on adjacent lands.

California Tiger Salamander Proposed Critical Habitat

The indirect effects of the action, as described above, are likely to destroy, degrade, or fragment essential aquatic, non-breeding, and dispersal and migration habitat of the California tiger salamander. The development that causes these effects will occur incrementally throughout the 40-year time period of the water service contract in both space and time. These effects will be permanent in duration and are likely to affect a substantial portion of the units 14, 15, and 16. We do not anticipate indirect effects of significance in unit 17 because this unit lies within the watershed of Los Vaqueros Reservoir and it does not lie within the prospective development envelope for urban growth within CCWD. However, with implementation of strategically situated conservation of California tiger salamander habitat concurrent with development through implementation of an interim conservation strategy or an ESA section 10(a)(1)(B) permit, we anticipate that the ability of the primary constituent elements to provide breeding, feeding, sheltering, dispersal and migration functions will be reduced in some areas but strengthened in other areas as other areas possessing primary constituent elements are protected and managed to conserve California tiger salamander. If implementation of conservation measures that remove threats and provide special management for California tiger salamander habitat concurrent with development occurs within the timeframes given in the **Description of the Proposed Action**, we anticipate that units 14, 15, 17, and 18 will maintain their conservation role of maintaining the current genetic structure; maintaining current geographic, elevational, and ecological distribution; protecting hydrology and water quality of breeding habitat; providing connectivity between breeding locations; and providing sufficient barrier-free upland habitat around breeding locations to allow for dispersal and migration.

Cumulative Effects

Cumulative effects are those effects of future State, Tribal, local or private actions that are reasonably certain to occur in the action area considered in this biological opinion. Future Federal actions unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the Act.

Because the CVP water is not the sole water supply for CCWD, all effects of reasonably foreseeable future development are not solely attributable to the Federal water supply and thus we consider many of them to be cumulative effects. We have not devised a way to quantitatively partition effects of growth in the CCWD service area among their Federal and non-Federal water sources in any but a fairly gross and qualitative fashion based on the water needs assessments of the respective agency. The water needs assessment describes the contribution of CVP water to the overall long term water needs and use of each entity from all available sources. We consider

the water needs assessment and existing land use planning documents of jurisdictions within the service areas of the two water purveyors indicative of the threshold extent and magnitude of future development and a gross indication of the increment of those effects related to the Federal water supply. For CCWD, the CVP contract provides the majority of water for raw water demands. As a result, we would attribute the majority of indirect effects of future urban growth within CCWD to the federal action rather than to cumulative effects.

California Red-legged Frog Proposed Critical Habitat

Within the action area, proposed critical habitat for the California red-legged frog occurs within the designated urban growth envelope of land use jurisdictions within CCWD. We anticipate cumulative effects from development will be the same as those described previously in the **Effects of the Proposed Action**, but reduced in scope and significance relative to those effects for the reasons described above.

California Tiger Salamander

Within the action area, the California tiger salamander occurs within the designated urban growth envelope of several jurisdictions within CCWD. We anticipate cumulative effects from development will be the same as those described previously in the **Effects of the Proposed Action** but reduced in scope and significance relative to those effects for the reasons described above.

California tiger salamander are exposed to other adverse cumulative effects within the action area, including predation of eggs and larvae by bullfrogs, exposure to environmental contaminants, and agricultural land conversion of upland aestivation habitat. We are aware of no offsetting measures or programs for these effects, but the total amount of California tiger salamander habitat within the action area is relatively small compared to the amount of habitat within the range of the species. The most significant cumulative effects, in terms of magnitude and extent, arise from future development in salamander habitat but the magnitude of these effects we expect to be substantially reduced by implementation of the proposed conservation measures. As a result, the overall significance of cumulative effects within the action area is minor.

California Tiger Salamander Proposed Critical Habitat

Within the action area, the California tiger salamander occurs within the designated urban growth envelope of several jurisdictions within CCWD. We anticipate cumulative effects from development will be the same as those described previously in the **Effects of the Proposed Action** but reduced in scope and significance relative to those effects for the reasons described above.

Conclusion

Regional Director

27

The Service hereby supplements the conclusion of biological opinion 1-1-99-F-0093 as follows:

It is also the Service's biological opinion that the proposed action is not likely to jeopardize the continued existence of the California tiger salamander or result in the destruction or adverse modification of proposed critical habitats for the California red-legged frog and the California tiger salamander. We base this conclusion on the conservation measures in the project description, particularly the one that requires an HCP to be signed and its Section 10 permit(s) issued prior to annual delivery of more than 148 TAF of CVP water. Because the present water demand is for 148 TAF of CVP water, this conservation measure ensures that the growth induced by additional CVP water deliveries will not occur until after an HCP is in place. The HCP will eventually ensure that development activities would avoid, minimize, and compensate for take of listed species.

Our conclusion that the proposed action will not adversely modify or destroy proposed critical habitat for California red-legged frog and California tiger salamander is premised on the assumption that implementation of conservation measures that remove threats to critical habitat and provide special management for California red-legged frog and California tiger salamander habitat concurrent with development will occur in accordance with the timeframes given in the **Description of the Proposed Action**. As a result, we anticipate that primary constituent elements will be secured and maintained, and that critical habitat will retain the ability serve the intended conservation role for each species. Although the City of Antioch is not a participant of the East Contra Costa County HCP, the HCP will be used as the standard to evaluate the conservation strategies contained in any future individual section 7 and 10 consultations conducted pursuant to the Act for new projects within the City of Antioch's boundaries.

The remainder of the Conclusion described in biological opinion 1-1-99-F-0093 remains unchanged.

INCIDENTAL TAKE STATEMENT

Amount or Extent of Take

The Service hereby adds the following to biological opinion 1-1-99-F-0093:

This biological opinion also does not authorize incidental take of California tiger salamanders.

The remainder of the Amount or Extent of Take described in biological opinion 1-1-99-F-0093 remains unchanged.

Effect of the Take

All Effect of the Take described in biological opinion 1-1-99-F-0093 remains unchanged.

Regional Director

28

Reasonable and Prudent Measures

All Reasonable and Prudent Measures described in biological opinion 1-1-99-F-0093 remain unchanged.

Terms and Conditions

Term and Condition 1(h) states:

"Reclamation shall not allocate the additional 40 TAF until the east county HCP is completed and the Section 10(a)(1)(B) permit(s) is (are) issued."

As stated in the consultation history of biological opinion 1-1-99-F-0093, limiting delta diversions to a maximum of 188 TAF (an additional 40 TAF over current demand) was intended to reduce take of delta smelt and Sacramento splittail (*Pogonichthys macrolepidotus*) (no longer protected under the Act). Because the Service's 2005 OCAP biological opinion (U.S. Fish and Wildlife Service 2005) addresses take of delta smelt and governs the delivery of CVP water, it supercedes biological opinion 1-1-99-F-0093 for delta smelt and its critical habitat. Therefore, Term and Condition 1(h) is hereby deleted. Once the East Contra Costa County HCP has been signed and the Section 10 permit(s) issued as required per the project description, Reclamation may deliver up to the full contract amount of 195 TAF.

All other Terms and Conditions described in biological opinion 1-1-99-F-0093 remain unchanged, and we add the following term and condition to implement reasonable and prudent measure number 3:

C. In accordance with conservation measures agreed to by CCWD, Reclamation shall not schedule more than 148,000 af annually of CVP water for delivery to CCWD service area until they receive verification from the Service that a section 10(a)(1)(B) permit has been issued for the East Contra Costa County HCP that addresses take of listed species associated with future growth in the CCWD water service area. Reclamation shall report to the SFWDO the actual annual quantity of CVP water delivered each year for both agricultural and M&I uses until the section 10(a)(1)(B) permit has been issued.

Reporting Requirements

All Reporting Requirements described in biological opinion 1-1-99-F-0093 remain unchanged.

CONSERVATION RECOMMENDATIONS

Regional Director

29

All Conservation Measures described in biological opinion 1-1-99-F-0093 remain unchanged. The Service further recommends the following:

1. That Reclamation and CCWD enhances and restores aquatic and wetland habitat in the Sacramento-San Joaquin River estuary as part of the CALFED program.
2. That Reclamation and CCWD actively participates in the development of a revised recovery plan for the Sacramento-San Joaquin Delta native fishes.
3. That Reclamation and CCWD encourages the City of Antioch to participate in the East Contra Costa County HCP or develop an HCP for growth within their City boundaries.

REINITIATION - CLOSING STATEMENT

This concludes the reinitiation and amendment of formal consultation and conference of biological opinion 1-1-99-F-0093. As provided in 50 CFR 402.16, re-initiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been maintained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the proposed action may affect listed species or critical habitat in a manner or to an extent not considered in this opinion; (3) the agency action is subsequently modified in a manner that causes an effect to listed species or critical habitat that was not considered in this opinion; or (4) a new species or critical habitat is designated that may be affected by the proposed action. In instances where the amount or extent of incidental take is exceeded, any operations causing such take must cease pending re-initiation.

If you have any questions about this request, please contact Mike Welsh or Jan Knight at (916) 414-5600.

cc:

ARD (ES), Portland, OR
Bureau of Reclamation, South-Central California Area Office, Fresno, CA (Attn: Kathy Wood)
Contra Costa Water District, Concord, CA (Attn: ??)

Regional Director

30

Literature Cited

- Austin, C. and H.B. Shaffer. 1992. Short-, medium-, and long-term repeatability of locomotor performance in the tiger salamander, *Ambystoma californiense*. *Functional Ecology* 6:145-153.
- Berrill, M., D. Coulson, L. McGilivray, and B. Paul. 1998. Toxicity of endosulfan to aquatic stages of anuran amphibians. *Environmental Toxicology and Chemistry* 17:1738-1744.
- Blaustein, A. R. and D. B. Wake. 1990. Declining amphibian populations: a global phenomenon? *Trends in Ecology and Evolution* 5(7): 203-204.
- Bridges, C. M. 1997. Tadpole swimming performance and activity affected by acute exposure to sublethal levels of carbaryl. *Environmental Toxicology and Chemistry* 16: 1935-1939.
- California Department of Pesticide Regulation Internet website, 2002. 2000 Annual pesticide use report preliminary data: Sonoma County Indexed by Commodity.
- California Natural Diversity Database (CNDDB). 2003. California Department of Fish and Game Computer report for U.S. Geological Survey 7.5-minute quadrangles: Benicia, Vine Hill, Honker Bay, Antioch North, Jersey Island, Bouldin Island, Walnut Creek, Briones valley, Clayton, Antioch South, Brentwood, Woodward Island, and Tassajara, Sacramento, CA.
- _____. 2004. Natural Heritage Division, California. Department of Fish and Game. State of California.
- de Llamas, M. C., A. C. de Castro, and A. M. P. de D'Angelo. 1985. Cholinesterase activities in developing amphibian embryos following exposure to the insecticides dieldrin and malathion. *Archives of Environmental Contamination and Toxicology* 14:161-166.
- Ganrati, S. C. and L. B. Kats. 1996. Effect of introduced crayfish and mosquitofish on California newts. *Conservation Biology* 10(4): 1155-1162.
- Hunt, L. E. 1998. Vernal pool amphibian management plan. Premier Partners III, Mesa Vineyard Property, Los Alamos Valley, Santa Barbara County, California. Prepared for County of Santa Barbara, Planning and Development Department, Santa Barbara, California.
- Jones and Stokes and Associates. 1987. Sliding toward extinction: California's natural heritage. Privately produced.
- Keeler-Wolf, T., D. R. Elam, K. Lewis, and S. A. Flint. 1998. California vernal pool assessment preliminary report. California Department of Fish and Game.

- Kuchler, A.W. 1988. The Map of the Natural Vegetation of California. Pp 909-938 and map in: M. G. Barbour and J. Major (Editors). Terrestrial Vegetation of California. California Native Plant Society, Special Publication No. 9.
- Loredo, I. and D. Van Vuren. 1996. Reproductive ecology of a population of the California tiger salamander. *Copeia* 1996(4): 895-901.
- Loredo, I., D. Van Vuren, and M. L. Morrison. 1996. Habitat use and migration behavior of the California tiger salamander. *Journal of Herpetology* 30(2): 282-285.
- Loredo-Prendeville, I., D. Van Vuren, A. J. Kuenzi, and M. L. Morrison. 1994. California ground squirrels at Concord Naval Weapons Station: alternatives for control and the ecological consequences. Pp. 72-77 *In* W. S. Halverson and A. C. Crabb (editors). Proceedings of the 16th Vertebrate Pest Conference. University of California Publications.
- Morey, S. R. and D. A. Guinn. 1992. Activity patterns, food habits, and changing abundance in a community of vernal pool amphibians. Pp. 149-157 *In* Williams, D. F., S. Byrne, T.A. Rado (editors). Endangered and Sensitive Species of the San Joaquin Valley, California. California Energy Commission, Sacramento, California . 1992.
- Rosenbaum, E. A., de Castro, C. Gauna, L., and D'Angelo, de. P. 1988. Early biochemical changes produced by Malathion on toad embryos.
- Seymour, R. and M. Westphal. 1994. Final Report - Status and habitat correlates of California tiger salamanders in the eastern San Joaquin Valley: results of the 1994 survey. Report prepared by the Coyote Creek Riparian Station for the U.S. Fish and Wildlife Service, Sacramento Office. 33 pp.
- Shaffer, H. B., R. N. Fisher, and S. E. Stanley. 1993. Status report: the California tiger salamander (*Ambystoma californiense*). Final report for the California Department of Fish and Game. 36 pp. plus figures and tables.
- Shaffer, H. B. and P. C. Trenham. 2002. Distinct Population Segments of the California Tiger Salamander. Section of Evolution and Ecology, and Center for Population Biology, University of California.
- Sparling, D. W., G. M. Fellers, and L. L. McConnell. 2001. Pesticides and amphibian population declines in California, USA. *Environmental Toxicology and Chemistry* 20(7): 1591-1595.
- Stebbins, R. C. 1962. Amphibians of the western United States. Ambystomids. University of California Press. Berkeley and Los Angeles. pp. 29-49 and plates.

- Stebbins, R. C. 1985. A field guide to western reptiles and amphibians. Houghton Mifflin Co. Boston, Massachusetts. Pp. 33-37.
- Storer, T. I. 1925. A synopsis of the amphibia of California. University of California Publications in Zoology 27: 60-71.
- Trenham, P. C. 1998a. Radio Tracking Information, unpublished manuscript. 6 pp.
- _____. 1998b. Demography, migration, and metapopulation structure of pond breeding salamanders. Unpublished Ph.D. dissertation. University of California, Davis. 96 pp.
- UCIPM, Internet website, January 2002.
- U.S. Bureau of Reclamation. 2004. Central Valley Project, Delta Division, Contra Costa Canal. Final Biological Assessment. Long-Term Water Service Contract Renewal. March 31, 2004. Volumes I and II.
- U. S. Fish and Wildlife Service. 1994. Endangered and threatened wildlife and plants. Determination of endangered status for the Conservancy fairy shrimp, longhorn fairy shrimp, and the vernal pool tadpole shrimp; and threatened status for the vernal pool fairy shrimp, Final Rule. 59 FR 48136-48153.
- _____. 2000a. Formal Consultation Pursuant to Section 7 of the Endangered Species Act of 1973, as Amended, on Contra Costa Water District's Construction of a Multipurpose Pipeline and Future Water Supply Implementation Program. Contra Costa County, California. 85 pp. plus attachment.
- _____. 2000b. Endangered and threatened wildlife and plants. Emergency rule to list the Santa Barbara County distinct population of the California tiger salamander as endangered. Rule and proposed rule. 65 FR 3096.
- _____. 2001. Final determination of critical habitat for the California red-legged frog. 66 FR 14626-14758.
- _____. 2002. Recovery Plan for the California red-legged Frog (*Rana aurora draytonii*). U.S. Fish and Wildlife Service, Portland, Oregon. viii + 173 pp.
- _____. 2003a. GIS.
- _____. 2003b. Final Designation of Critical Habitat for four Vernal Pool Crustaceans and Eleven Vernal Pool Plants in California and Southern Oregon. 68 FR 46684-46867.

_____. 2004a. Formal and Early Section 7 Endangered Species Consultation on the Coordinated Operations of the Central Valley Project and State Water Project and the Operational Criteria and Plan. Sacramento, California. 231 pp.

_____. 2004b. Endangered and threatened wildlife and plants. Determination of threatened status for the Central California Distinct Population Segment of the California tiger salamander and special rule exemption for existing routing ranching activities. Final Rule. 69 **FR**. 47212-47248

_____. 2004c. Endangered and threatened wildlife and plants. Designation of critical habitat for the central population of the California tiger salamander. Proposed Rule. 69 **FR**. 48570-48649.

_____. 2004d. Endangered and threatened wildlife and plants. Proposed Designation of Critical Habitat for the California Red-legged Frog (*Rana aurora draytonii*). Proposed rule. 69 **FR**. 19620-19642.

_____. 2005. Reinitiation of Formal and Early Section 7 Endangered Species Consultation on the Coordinated Operations of the Central Valley Project and State Water Project and the Operational Criteria and Plan to Address Potential Critical Habitat Issues (1-1-05-F-0055) U.S. Fish and Wildlife Service, Sacramento Fish and Wildlife Office, Sacramento California. February 15, 2005.

Wathman, J. D., R. A., Sweitzer, D. Van Vuren, and, J. D. Drew, JD, Bri *et al.* 1999.

In Litt

Bulger, J. B., N. J. Scott, and R. B. Seymour. 2000. Letter to Curt McCasland, Fish and Wildlife Biologist, SFWO, regarding manuscript summarizing California red-legged frog field study conducted in Santa Cruz County, California during 1997-1998 field season. April 3, 2000.

Boyce, K. 1994. Beneficials: mosquitofish. Sacramento County/Yolo County Mosquito and Vector Control District.

Jones, T.R., Ph.D., School of Natural Resources and Environment, University of Michigan. 27 January 1993 letter to Mike Long, U.S. Fish and Wildlife Service, with attached draft manuscript.

Sweet, Samuel S. Associate Professor, U.C.S.B., Santa Barbara, CA. Letter to Mr. Wayne S. White, U.S. Fish and Wildlife Service, Sacramento, CA, regarding the threats to the western pond turtle and California red-legged frog. January 19, 1993.

Sweet, S., University of California, Santa Barbara. 31 August 1998 letter to Dwight Harvey, U.S. Fish and Wildlife Service. With enclosed report, "Vineyard development posing an imminent threat to *Ambystoma californiense* in Santa Barbara County, California".

Wake, D. University of California, Berkeley, California. 1992.

Personal Communication

Shaffer and Trenham, UCD, pers. comm 2003

Sweet, S. University of California, Santa Barbara. 28 February 1998 Telephone conversation.



United States Department of the Interior



FISH AND WILDLIFE SERVICE

California and Nevada Region
2800 Cottage Way, Room W-2606
Sacramento, California 95825-1846

In reply refer to:
81420-2008-F-1481-5

Memorandum

To: Operation Manager, Bureau of Reclamation, Central Valley Operations Office
Sacramento, California

From: Regional Director, Fish and Wildlife Service, Region 8, Sacramento, California

Subject: Formal Endangered Species Act Consultation on the Proposed Coordinated
Operations of the Central Valley Project (CVP) and State Water Project (SWP)

This is in response to the Bureau of Reclamation's (Reclamation) May 16, 2008, request for formal consultation with the Fish and Wildlife Service (Service) on the coordinated operations of the CVP and SWP in California. Reclamation is the lead Federal agency and the California Department of Water Resources (DWR) is the Applicant for this consultation. Your revised biological assessment was received in our office on August 20, 2008. This document represents the Service's biological opinion on the effects of the subject action to the threatened delta smelt (*Hypomesus transpacificus*) and its designated critical habitat. This response is provided in accordance with the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*) (Act).

Reclamation also requested consultation on the effects of the proposed action on the endangered riparian brush rabbit (*Sylvilagus bachmani riparius*), endangered riparian woodrat (*Neotoma fuscipes riparia*), endangered salt marsh harvest mouse (*Reithrodontomys raviventris*), endangered California clapper rail (*Rallus longirostris obsoletus*), threatened giant garter snake (*Thamnophis gigas*), threatened California red-legged frog (*Rana aurora draytonii*), threatened valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*), endangered soft bird's-beak (*Cordylanthus mollis ssp. Mollis*), and the endangered Suisun thistle (*Cirsium hydrophilum var. hydrophilum*). Reclamation determined that the proposed continued operations of the CVP and SWP are not likely to adversely affect these listed species. The Service concurs with Reclamation's determination that the coordinated operations of the CVP and SWP are not likely to adversely affect these species.

The Service conducted a comprehensive peer review of this biological opinion. We formed an Internal Peer Review Team (IPRT), which consisted of individuals from throughout the Service who are experts in the development of complex biological opinions under the ESA. The IPRT reviewed the biological opinion and provided substantive input and comments. Additionally, the Service assembled a team of delta smelt experts from within the Service, California Department

of Fish and Game, Environmental Protection Agency, Reclamation and other academics to provide scientific and technical expertise into the review of the biological assessment and the development of the biological opinion. The Service also contracted with PBS&J, an environmental consulting firm, who formed an independent review team consisting of experts on aquatic ecology and fishery biology to conduct a concurrent review of the draft Effects Section of the biological opinion at the same that we provided the Effects Section to Reclamation and DWR for their review. The Service received the results of the independent review of the draft Effects Section on October 23, 2008; DWR and Reclamation provided the results of their review on October 24, 2008. The Service modified the Effects Section of the biological opinion, as appropriate, based on the comments received from the IPRT, the independent review team, Reclamation and DWR. The Service also contracted with PBS&J to conduct an independent review of the draft Actions (Final shown in Attachment B), as well as a review of DWR's proposed actions. The Service simultaneously provided the draft Actions to Reclamation and DWR for their review. The Service received Reclamation's and DWR's comments on the draft Actions on November 5, 2008. The Service received the results of the independent review of both the Service's and DWR's draft Actions on November 19, 2008. The Service's actions were then modified to respond to comments from the independent review team and in consideration of comments received from DWR. A draft biological opinion was provided to Reclamation on November 21, 2008. Comments were received back from Reclamation and DWR on December 2, 2008. The Service has incorporated all comments and edits, as appropriate, into this biological opinion.

This biological opinion is based on information provided in Reclamation's biological assessment dated August 20, 2008, associated appendices, and input from the various internal and external review processes that the Service has utilized in this consultation, described immediately above. A complete administrative record is on file at the Sacramento Fish and Wildlife Office (SFWO).

Consultation History

July 30, 2004	The Service issued a biological opinion addressing <i>Formal and Early Section 7 Endangered Species Consultation on the Coordinated Operations of the Central Valley Project and State Water Project and the Operations Criteria and Plan to Address Potential Critical Habitat Issues</i> (Service file # 1-1-04-F-0140).
February 15, 2005	The Department of the Interior is sued on the July 30, 2004 biological opinion.
February 16, 2005	The Service issued its <i>Reinitiation of Formal and Early Section 7 Endangered Species Consultation on the Coordinated Operations of the Central Valley Project and State Water Project and the Operational Criteria and Plan to Address Potential Critical Habitat Issues</i> (Service file # 1-1-05-F-0055).
May 20, 2005	The Department of the Interior is sued on the February 16, 2005 biological opinion.
February 2006 through September 2008	Staff from the California Department of Fish and Game (DFG), DWR, National Marine Fisheries Service (NMFS), Reclamation, and the Service (OCAP Working Team) met monthly to bi-weekly to discuss the development of the biological assessment.
July 6, 2006	Reclamation requested informal consultation on coordinated operations of the CVP and SWP and their effects to delta smelt.
May 25, 2007	Judge Wanger issued a summary judgment that invalidated the 2005 biological opinion and ordered a new biological opinion be developed by September 15, 2008.
May 31, 2007	The Service provided Reclamation with guidance and recommendations concerning the project description used in the 2004 biological opinion.
August 20, 2007	The Service provided a memorandum to Reclamation containing a species list for the proposed action and clarification of the formal consultation timeline.
October 29, 2007	The Service received an electronic version of the draft project description for the biological assessment (Chapter 2) dated August 2007.
December 4, 2007	DFG, NMFS, and the Service received a draft project description dated December 4, 2007.

December 6, 2007	DFG, NMFS, and the Service provided Reclamation with joint preliminary guidance and recommendations for part of the draft project description of CVP operations received on December 4, 2007.
December 14, 2007	Judge Wanger issued an interim order to direct actions at the export facilities to protect delta smelt until a new biological opinion is completed.
December 20, 2007	DFG, NMFS, and the Service provided Reclamation with joint preliminary guidance and recommendations for parts of the draft project description of SWP operations received on December 4, 2007.
January 17, 2008	DFG, NMFS, and the Service provided Reclamation with joint preliminary guidance and recommendations for the remaining portion of the draft project description received on December 4, 2007.
January 21, 2008	The Service sent to Reclamation an electronic version of the entire draft project description with guidance and recommendations developed jointly by DFG, NMFS, and the Service.
January 22, 2008	Reclamation provided DFG, NMFS and the Service with an electronic version of the description of operations of the Suisun Marsh Salinity Control Gates (SMSCG) dated August 2007.
January 23, 2008	DFG, NMFS, and the Service provided DWR with joint preliminary guidance and recommendations on the December 4, 2007, draft project description.
March 4, 2008	The Service provided DWR with joint DFG and Service guidance and recommendations for the August 2007 version of the proposed Suisun Marsh Salinity Control Gate (SMSCG) operations description.
March 6, 2008	DWR provided the Service with an updated description of proposed operations of the SMSCG.
March 10, 2008	The Service received a draft description and effects analysis of aquatic weed management in Clifton Court Forebay.
March 24, 2008	DFG, NMFS, and the Service provided Reclamation with guidance and recommendations on the aquatic weed management section of the biological assessment.
April 21, 2008	Reclamation provided the Service with a revised draft project description for the biological assessment.

April 28 through May 2, 2008	Reclamation conducted an external technical review of their draft biological assessment.
May 2008 through December 2008	Numerous meeting between the Service, Reclamation, DWR, DFG and NMFS on the development of the biological assessment and the biological opinion.
May 8, 2008	The fisheries agencies provided Reclamation and DWR with guidance and recommendations on the draft project description dated April 21, 2008.
May 16, 2008	The Service received a letter from Reclamation dated May 16, 2008, requesting formal consultation on the proposed action. A biological assessment also dated May 16, 2008, was enclosed with the letter.
May 17, 2008	Reclamation provided the Service with a number of revisions and addenda to the May 16, 2008 biological assessment.
May 28, 2008	Reclamation and DWR provided the Service with additional revisions to the May 16, 2008 biological assessment.
May 29, 2008	The Service sent a memo to Reclamation stating that with the revisions provided on May 28, 2008, the Service had received enough information to start the 30-day review period.
June 27, 2008	The Service provided Reclamation with a memo requesting additional information.
July 2, 2008	The Service received a memorandum from Reclamation informing the Service that Reclamation is committed to providing a response to the Services' June 27, 2008, request for additional information by early August, 2008.
August 11, 2008	The Service received Reclamation's August 8, 2008, letter transmitting the revised biological assessment.
August 20, 2008	The Service received the revised biological assessment on electronically from Reclamation.
August 29, 2008	Judge Wanger extended the completion date for the coordination of the CVP and SWP biological opinion to December 15, 2008.
September 25, 2008	The Service received a letter dated September 24, 2008 from the San Luis & Delta-Mendota Water Authority and the State Water Contractors, which provided comments on the biological assessment.
October 17, 2008	The Service received DWR's October 16, 2008 draft conservation actions.

October 17 through 24, 2008	Review of the draft Effects section of the biological opinion by the Service's Internal Peer Review Team (IPRT).
October 17 through 24, 2008	Independent Review of the draft Effects section of the biological opinion conducted by PBS&J.
October 23, 2008	The Service received a letter dated October 20, 2008 from the San Luis & Delta-Mendota Water Authority and the State Water Contractors, which provided comments on fall X2.
October 24, 2008	The Service received comments from Reclamation and DWR on the draft Effects section.
October 24 through November 19, 2008	Review of entire preliminary draft biological opinion by IPRT.
October 24 through November 19, 2008	Independent Review of the Service's draft conservation actions and DWR's draft conservation actions conducted by PBS&J. The Service's draft actions were also submitted to Reclamation.
November 21, 2008	The Service transmitted the draft biological opinion to Reclamation.
November 24, 2008	The Service received a letter dated November 19, 2008 from the San Luis & Delta-Mendota Water Authority and the State Water Contractors, which provided comments on the Effects section and the review conducted by PBS&J.
December 2, 2008	The Service received comments from Reclamation and DWR on the draft biological opinion.

Table of Contents

Consultation History	iii
Project Description	1
COORDINATED OPERATIONS OF THE CVP AND SWP	19
Coordinated Operations Agreement	19
Implementing the COA.....	19
Obligations for In-Basin Uses.....	19
Accounting and Coordination of Operations.....	20
State Water Resources Control Board Water Rights	21
1995 Water Quality Control Plan.....	21
Decision 1641	21
Joint Points of Diversion.....	26
Revised WQCP (2006).....	27

REAL TIME DECISION-MAKING TO ASSIST FISHERY MANAGEMENT	27
Introduction	27
Framework for Actions	28
Water Operations Management Team	28
Process for Real Time Decision- Making to Assist Fishery Management	28
Groups Involved in Real Time Decision-Making to Assist Fishery Management and Information Sharing	29
Information Teams	29
CALFED Ops and Subgroups	29
Data Assessment Team (DAT)	29
Integrated Water Operations and Fisheries Forum	29
B2 Interagency Team (B2IT)	30
Technical Teams	30
The Sacramento River Temperature Task Group (SRTTG)	30
Smelt Working Group (SWG)	30
Delta Smelt Risk Assessment Matrix (DSRAM)	31
The Salmon Decision Process	31
American River Group	31
San Joaquin River Technical Committee (SJRTC)	31
Operations Technical Teams	32
Delta Cross Channel Project Work Team	32
Gate Operations Review Team	32
Uses of Environmental Water Accounts	32
CVPIA Section 3406 (b)(2)	32
CVPIA 3406 (b)(2) Operations on Clear Creek	33
CVPIA 3406 (b)(2) Operations on the Upper Sacramento River	33
CVPIA 3406 (b)(2) Operations on the Lower American River	33
CVPIA 3406 (b)(2) Operations in the Delta	34
500 CFS DIVERSION INCREASE DURING JULY, AUGUST, AND SEPTEMBER	35
CENTRAL VALLEY PROJECT	37
Central Valley Project Improvement Act	37
Water Service Contracts, Allocations and Deliveries	37
Water Needs Assessment	37
Future American River Operations - Water Service Contracts and Deliveries	38
Water Allocation – CVP	38
CVP M&I Water Shortage Operational Assumptions	38
Project Facilities	39
Trinity River Division Operations	39
Safety of Dams at Trinity Reservoir	42
Fish and Wildlife Requirements on Trinity River	42
Transbasin Diversions	43
Whiskeytown Reservoir Operations	45
Spillway Flows below Whiskeytown Lake	45
Fish and Wildlife Requirements on Clear Creek	46
Spring Creek Debris Dam Operations	47
Shasta Division and Sacramento River Division	48
Flood Control	49
Fish and Wildlife Requirements in the Sacramento River	50
Minimum Flow for Navigation – Wilkins Slough	51
Water Temperature Operations in the Upper Sacramento River	52
SWRCB Water Rights Order 90-05 and Water Rights Order 91-01	52
Shasta Temperature Control Device	53
Reclamation's Proposed Upper Sacramento River Temperature Objectives	54
Anderson-Cottonwood Irrigation District (ACID) Diversion Dam	54
Red Bluff Diversion Dam Operations	55
American River Division	55
Flood Control	57
Fish and Wildlife Requirements in the Lower American River	59

Delta Division and West San Joaquin Division	63
CVP Facilities	63
Delta Cross Channel Operations	65
Jones Pumping Plant	66
Tracy Fish Collection Facility	66
Contra Costa Water District Diversion Facilities	68
Water Demands—Delta Mendota Canal (DMC) and San Luis Unit	70
East Side Division	70
New Melones Operations	70
Flood Control	72
Requirements for New Melones Operations	72
Water Rights Obligations	73
In-stream Flow Requirements	73
Dissolved Oxygen Requirements	74
Vernalis Water Quality Requirement	74
Bay-Delta Vernalis Flow Requirements	74
CVP Contracts	74
New Melones Operations	75
New Melones Reservoir – Future Operations	76
San Joaquin River Agreement/Vernalis Adaptive Management Plan (VAMP)	78
Water Temperatures	79
San Felipe Division	80
Friant Division	81
STATE WATER PROJECT	82
Project Management Objectives	83
Clifton Court Forebay	83
Water Service Contracts, Allocations, and Deliveries	86
Monterey Agreement	88
Changes in DWR's Allocation of Table A Water and Article 21 Water	89
Historical Water Deliveries to Southern California	89
Project Facilities	90
Oroville Field Division	90
Current Operations - Minimum Flows and Temperature Requirements	92
Feather River Flow Requirements	95
Low Flow Channel	95
High Flow Channel	95
Temperature Requirements	96
Low Flow Channel	96
High Flow Channel	96
Flood Control	100
Feather River Ramping Rate Requirements	100
Proposed Operational Changes with the Federal Energy Regulatory Commission (FERC) Relicensing of the Oroville Project— Near Term and Future Operations	101
Minimum Flows in the Low Flow and High Flow Channels	102
Water Temperatures for the Feather River Fish Hatchery	102
Water Temperatures in the Lower Feather River	104
Habitat Expansion Agreement	106
Anadromous Fish Monitoring on the Lower Feather River	107
Delta Field Division	107
Clifton Court Forebay Aquatic Weed Control Program	108
Proposed Measures to Reduce Fish Mortality	110
North Bay Aqueduct Intake at Barker Slough	111
COORDINATED FACILITIES OF THE CVP AND SWP	112
Joint Project Facilities	112
Suisun Marsh	112
CALFED Charter for Development of an Implementation Plan for Suisun Marsh Wildlife Habitat Management and Preservation	113
Suisun Marsh Salinity Control Gates	114
SMSCG Fish Passage Study	116

Roaring River Distribution System	117
Morrow Island Distribution System	118
South Delta Temporary Barriers Project	119
Proposed Installation and Operations of the Temporary Barriers	119
Conservation Strategies and Mitigation Measures	120
San Luis Complex	120
San Luis Unit Operation	123
Transfers	126
Transfer Capacity	128
Proposed Exports for Transfers	129
OTHER PROJECTS	129
DMC/CA Intertie Proposed Action	129
Location	130
Operations	130
Freeport Regional Water Project	131
Alternative Intake Project	132
Red Bluff Diversion Dam Pumping Plant	133
South Delta Improvements Program Stage 1	133
South Delta Gates	134
Head of Old River Fish Control Gate	136
Spring Operations/ Real Time Decision Making	136
Summer and Fall Operations	136
Flow Control Gates	137
Spring Operations	137
Summer and Fall Operations	137
Gate Operations and Jones and Banks Exports	138
State Water Project Oroville Facilities	138
Analytical Framework for the Jeopardy Determination	138
Analytical Framework for the Adverse Modification Determination	139
Status of the Species/Environmental Baseline	140
DELTA SMELT	140
Delta Smelt Species Description and Taxonomy	140
Existing Monitoring Programs	143
Overview of Delta Smelt's Life Cycle	145
Biology and Life History	147
Spawning	147
Larval Development	148
Juveniles	150
Foraging Ecology	151
Habitat	152
Delta Smelt Population Dynamics and Abundance Trends	153
FACTORS AFFECTING THE SPECIES	159
Water Diversions and Reservoir Operations	159
Banks and Jones Export Facilities	159
Environmental Water Account	166
500 cfs Diversion at Banks	166
CVP/SWP Actions Taken since the 2005 OCAP Biological Opinion was Issued	167
Water Year 2008 Interim Remedial Order Following Summary Judgment and Evidentiary Hearing (Wanger Order)	168
Water Transfers	169
Article 21 and changes to Water Deliveries to Southern California	169

Vernalis Adaptive Management Plan.....	169
Other SWP/CVP Facilities.....	170
North Bay Aqueduct.....	170
Contra Costa Water District (CCWD)	171
Other Delta Diversions and Facilities	172
Delta Power Plants.....	173
Delta Cross Channel	174
South Delta Temporary Barriers.....	174
Suisun Marsh Salinity Control Gates.....	175
Upstream Diversion and Reservoir Operations.....	176
Trinity River	176
Seasonal Life History of Delta Smelt.....	177
Winter (December-February).....	177
Spring (March-May).....	177
Summer (June-August)	178
Fall	178
Other Stressors	182
Aquatic Macrophytes	182
Predators	183
Competition	183
Delta Smelt Feeding.....	184
Delta Food Web	184
Suisun Bay Region.....	184
Delta.....	185
Microcystis	186
Contaminants.....	186
Climate Change	188
SUMMARY OF DELTA SMELT STATUS AND ENVIRONMENTAL BASELINE	189
SURVIVAL AND RECOVERY NEEDS OF DELTA SMELT	189
DELTA SMELT CRITICAL HABITAT	190
Description of the Primary Constituent Elements	190
Conservation Role of Delta Smelt Critical Habitat.....	191
Overview of Delta Smelt Habitat Requirements and the Primary Constituent	
Elements	192
Conservation Function of Primary Constituent Elements by Life History	
Stage.....	192
<i>Spawning.....</i>	192
<i>Larval and Juvenile Transport.....</i>	193
<i>Juvenile Rearing</i>	194
<i>Adult Migration.....</i>	195
<i>Current Condition of Delta Smelt Critical Habitat and Factors that Contribute to that Condition.....</i>	195
PCE #1 - Physical Habitat for Spawning	196
PCE #2 - Water for All Life Stages (Suitable Quality)	196
<i>Factors that Impair/Degrade the Function of PCE #2.....</i>	197
CVP and SWP.....	197
Aquatic Macrophytes	198
Contaminants	198
Nonnative Species.....	198
PCE #3 - River Flow for Larval and Juvenile Transport, Rearing, and Adult	
Migration.....	198
<i>Factors that Impair/Degrade the Function of PCE #3</i>	199
CVP and SWP.....	199
Environmental Water Account.....	199
Special Management for PCE #3	200
Vernalis Adaptive Management Plan	200

PCE #4 - Salinity for Rearing.....	200
Factors that Impair/Degrade the Function of PCE #4	200
CVP and SWP	200
Environmental Water Account.....	201
Other Factors that May Influence the Condition of PCE #4.....	201
Aquatic Macrophytes	201
Nonnative Species.....	202
Climate Change.....	202
Effects of the Proposed Action	202
INTRODUCTION.....	202
DATA AND MODELS USED IN THE ANALYSIS	204
EFFECTS ANALYSIS METHODS	208
MIGRATING AND SPAWNING ADULTS (~ DECEMBER THROUGH MARCH)	209
Water Diversions and Reservoir Operations.....	209
<i>Upstream Reservoirs and Diversions.....</i>	209
<i>Banks and Jones Pumping Plants</i>	209
Entrainment.....	209
Adult Entrainment.....	210
OMR Flows	211
Salvage and Entrainment Loss Predictions.....	211
Predicted Salvage and Entrainment.....	212
Article 21	215
DMC-CA Intertie	216
NBA Diversion	216
CCWD Diversions.....	217
Old River intake.....	217
Rock Slough.....	217
Alternative Intake.....	218
Suisun Marsh Salinity Control Gates.....	218
LARVAL AND JUVENILE DELTA SMELT (~ MARCH-JUNE)	219
Water Diversions and Reservoir Operations.....	219
<i>Banks and Jones.....</i>	219
Historical Data (1967-2007).....	221
<i>Combined Old and Middle River Flow</i>	221
<i>Delta Outflow.....</i>	221
<i>Predicted entrainment.....</i>	221
Proposed Action.....	222
<i>Combined Old and Middle River Flow</i>	222
<i>X2.....</i>	222
<i>Effects of Forecasted Operations</i>	222
Article 21	223
VAMP.....	223
Intertie.....	224
NBA Diversion	224
CCWD Diversions.....	224
Old River Intake.....	224
Rock Slough.....	225
Alternative Intake.....	225
<i>South Delta Temporary Barriers.....</i>	225
Hydrodynamic Effects.....	225
Vulnerability to Local Agricultural Diversions.....	226
Effects to Potential Fish Prey Items	226
<i>South Delta Permanent Operable Gates</i>	226
Hydrodynamic Effects.....	226
Vulnerability to Local Agricultural Diversions.....	227
Effects to Potential Fish Prey Items	227

<i>Suisun Marsh Salinity Control Gates</i>	227
<i>American River Demands</i>	227
<i>Delta Cross Channel</i>	227
JUVENILES AND ADULTS (~ JULY-DECEMBER)	228
Entrainment of <i>Pseudodiaptomus forbesi</i> (June-September)	228
Water Transfers	229
<i>Post-processing of Model Data for Transfers</i>	229
<i>Limitations</i>	230
<i>Proposed Exports for Transfers</i>	230
JPOD	231
500 cfs at Banks	231
NBA Diversion	231
CCWD Diversions	232
Temporary Agricultural Barriers	232
Permanent Operable Gates	232
American River Demands	232
Delta Cross Channel	232
Entrainment Effects	233
<i>Water Diversions and Reservoir Operations</i>	233
<i>Banks and Jones</i>	233
<i>Intertie</i>	233
<i>Suisun Marsh Salinity Control Gates</i>	233
Habitat Suitability (Sept-Dec)	233
<i>X2</i>	235
<i>Area of Suitable Abiotic Habitat</i>	235
<i>Effect on Delta Smelt Abundance</i>	236
<i>Additional Long-term Trends and Potential Mechanisms</i>	236
American River Demands	238
Komeen Treatment	238
Effects to Delta Smelt Critical Habitat	239
PRIMARY CONSTITUENT ELEMENTS	239
Spawning Habitat	239
PCE 1 – Physical Habitat	239
PCE 2 – Water	239
PCE 3 – River Flow	240
PCE 4 – Salinity	240
Larval and Juvenile Transport	240
PCE 1 – Physical Habitat	240
PCE 2 – Water	240
PCE 3 – River Flows	241
PCE 4 – Salinity	241
Rearing Habitat	242
PCE 1 – Physical Habitat	242
PCE 2 – Water	242
PCE 3 – River Flows	242
PCE 4 – Salinity	243
Adult Migration	243
PCE 1 – Physical Habitat	243
PCE 2 – Water	243
PCE 3 – River Flows	243
PCE 4 – Salinity	244
Summary of Effects of the Action on Delta Smelt Critical Habitat	244
CUMULATIVE EFFECTS	244

CONCLUSION	276
Delta Smelt	276
Delta Smelt Critical Habitat	278
Reasonable and Prudent Alternative	279
Incidental Take Statement	285
REASONABLE AND PRUDENT MEASURES	294
Terms and Conditions	294
MONITORING REQUIREMENTS	295
REPORTING REQUIREMENTS	295
Conservation Recommendations	295
Reinitiation-Closing Statement	296
Literature Cited	298
Attachment A-Delta Smelt Risk Assessment Matrix	311
Attachment B, Supplemental Information related to the Reasonable and Prudent Alternative	324
Attachment C: Methods Used in Developing the Incidental Take Statement	382

4. On the basis of findings (1)-(3) above, the Service concludes that implementation of the proposed action is likely to prevent delta smelt critical habitat from serving its intended conservation role.

Reasonable and Prudent Alternative

The regulations (50 CFR 402.02) implementing section 7 of the Act define reasonable and prudent alternatives (RPA) as alternative actions, identified during formal consultation, that: 1) can be implemented in a manner consistent with the intended purpose of the action; 2) can be implemented consistent with the scope of the action agency's (i.e. Reclamation's) legal authority and jurisdiction; 3) are economically and technologically feasible; and, 4) would, the Service believes, avoid the likelihood of jeopardizing the continued existence of listed species or resulting in the destruction or adverse modification of critical habitat.

The Service has developed the following RPA that includes four components to be implemented using an adaptive approach within specific constraints. The fifth component includes monitoring and reporting requirements. The components presented below are based on the best available scientific information regarding what is necessary to adequately provide for successful delta smelt migration and spawning, and larval and juvenile survival, growth, rearing, and recruitment within the Bay-Delta.

The specific flow requirements, action triggers and monitoring stations prescribed in the RPA will be continuously monitored and evaluated consistent with the adaptive process. As new information becomes available, these action triggers may be modified without necessarily requiring re-consultation on the overall proposed action.

The following actions are necessary to ensure that implementation of the long term operations of the CVP/SWP does not appreciably reduce the likelihood of both the survival and recovery of the delta smelt and does not preclude the intended conservation role of its critical habitat through: 1) preventing/reducing entrainment of delta smelt at Jones and Banks; 2) providing adequate habitat conditions that will allow the adult delta smelt to successfully migrate and spawn in the Bay-Delta; 3) providing adequate habitat conditions that will allow larvae and juvenile delta smelt to rear; and 4) providing suitable habitat conditions that will allow successful recruitment of juvenile delta smelt to adulthood. In addition, it is essential to monitor delta smelt abundance and distribution through continued sampling programs through the IEP.

Detailed descriptions of the adaptive process, its framework, and the rationale for each of the RPA components are presented in Attachment B of this biological opinion.

Process for Determining Specific Actions within Components 1 and 2

1. Within one day after the SWG recommends an action should be initiated, changed, suspended or terminated, the SWG shall provide to the Service a written recommendation and a biological justification. The SWG shall use the process described in Attachments A and B to provide a framework for their recommendations. The Service shall determine whether the proposed action should be implemented, modified, or terminated; and the OMR flow needed to achieve the protection. The Service shall present this information to the WOMT.
2. The WOMT shall either concur with the recommendation or provide a written alternative to the recommendation to the Service within one calendar day. The Service shall then make a final determination on the proposed action to be implemented, which shall be documented and posted on the Sacramento Fish and Wildlife Service's webpage.
3. Once the Service makes a final determination to initiate a new action, it shall be implemented within two calendar days by Reclamation and DWR, and shall remain in effect until the need for the action ends or the OMR flow is changed, as determined by the Service, consistent with the RPA and described within Attachment B. Data demonstrating the implementation of the action shall be provided by Reclamation to the Service on a weekly basis.
4. If the Service determines that an OMR flow change is required while an action is ongoing, Reclamation and DWR shall adjust operations to manage to the new OMR flow within two days of receipt of the Service's determination. This new OMR flow shall be used until it is adjusted or the action is changed or terminated based on new information, as described in the RPA and Attachment B.

RPA Component 1: Protection of the Adult Delta Smelt Life Stage

Delta smelt are entrained at the fish facilities each year. These actions are designed to reduce the delta smelt entrainment losses. The objective of Component 1 (Actions 1 and 2 in Attachment B) is to reduce entrainment of pre-spawning adult delta smelt during December to March by controlling OMR flows during vulnerable periods. Action 1 is designed to protect upmigrating delta smelt. Action 2 is designed to protect adult delta smelt that have migrated upstream and are residing in the Delta prior to spawning. Overall, RPA Component 1 will increase the suitability of spawning habitat for delta smelt by decreasing the amount of Delta habitat affected by the projects' export pumping plants' operations prior to, and during, the critical spawning period.

Beginning in December of each year, the Service shall review data on flow, turbidity, salvage, and other parameters that have historically predicted the timing of delta smelt migration into the Delta. On an ongoing basis, and consistent with the parameters outlined below and in Attachment B, the SWG shall recommend to the Service OMR flows that are expected to minimize entrainment of adult delta smelt. Throughout the

implementation of RPA Component 1, the Service will make the final determination as to OMR flows required to protect delta smelt.

OMR flow requirements given below are based on the following understanding: Where a 14-day running average is established, the average daily OMR flow must be no more negative than the required OMR flow. Where a 5-day running average is given, the daily average shall be no more than 25 percent more negative than the requirement. The daily OMR flows used to compute both the 14-day and the 5-day averages shall be the “tidally filtered” values reported by USGS.

Low-entrainment risk period: delta smelt salvage has historically been low between December 1 and December 19, even during periods when first flush conditions (i.e., elevated river inflow and turbidity) occurred. During the low-entrainment risk period, the SWG shall determine if the information generated by physical (i.e. turbidity and river inflow) and biological (e.g., salvage, DFG trawls) monitoring indicates that delta smelt are vulnerable to entrainment or are likely to migrate into a region where future entrainment events may occur. If this occurs, the Service shall require initiation of Action 1 as described in Attachment B. Action 1 shall require the Projects to maintain OMR flows no more negative than -2,000 cfs (14-day average) with a simultaneous 5-day running average flow no more negative than -2,500 cfs to protect adult delta smelt for 14 days.

High-entrainment risk period: delta smelt have historically been entrained when first flush conditions occur in late December. In order to prevent or minimize such entrainment, Action 1 shall be initiated on or after December 20 if the 3 day average turbidity at Prisoner’s Point, Holland Cut, and Victoria Canal exceeds 12 NTU, or if there are three days of delta smelt salvage at either facility or if the cumulative daily salvage count is above the risk threshold based upon the “daily salvage index” approach described in Attachment B. Action 1 shall require the Projects to maintain OMR flows no more negative than -2,000 cfs (14-day running average) with a simultaneous 5-day running average flow no more negative than -2,500 cfs to protect adult delta smelt for 14 days. However, the SWG can recommend a delayed start or interruption based on other conditions such as delta inflow that may affect vulnerability to entrainment.

Winter protection period: recent analyses indicate that cumulative adult entrainment and salvage are lower when OMR flows are no more negative than -5,000 cfs in the December through March period. Action 2 shall commence immediately after Action 1 ends. If Action 1 is not implemented, the SWG may recommend a start date for the implementation of Action 2 to protect adult delta smelt. OMR flows under Action 2 shall be in the range of -3,500 to -5,000 when turbidity and salvage are low. Based on historic conditions, OMR flow would generally be expected to be in the range of -2,000 cfs to -3,500 cfs given recent salvage events. However, at times when turbidity and flow conditions in the Delta may result in increased salvage, the range may be between -1,250 to -2,000 cfs. During the implementation of Action, the maximum negative flow for OMR shall be determined based on the criteria outlined in Attachment B. The OMR flow shall be based on a 14-day running average with simultaneous 5-day running average

within 25 percent of the required OMR flow. The action may be suspended temporarily if the three day flow average is greater than or equal to 90,000 cfs at the Sacramento River at Rio Vista and 10,000 cfs at the San Joaquin River at Vernalis, because there is low likelihood that delta smelt will be entrained during such high inflow conditions. Suspension of this action due to high flow will end when flow drops below the 90,000 cfs and 10,000 cfs threshold. Action 2 ends when spawning begins as defined for Action 3 implementation (Component 2).

RPA Component 2: Protection of Larval and Juvenile Delta Smelt

Delta smelt larvae and juveniles are susceptible to direct mortality by entrainment. Hydrologic conditions resulting from CVP/SWP operations increase the risk of that entrainment. The objective of this RPA component (which corresponds to Action 3 in Attachment B), is to improve flow conditions in the Central and South Delta so that larval and juvenile delta smelt can successfully rear in the Central Delta and move downstream when appropriate.

Upon completion of RPA Component 1 or when Delta water temperatures reach 12°C (based on a 3-station average of daily average water temperature at Mossdale, Antioch, and Rio Vista) or when a spent female delta smelt is detected in the trawls or at the salvage facilities, the projects shall operate to maintain OMR flows no more negative than -1,250 to -5000 cfs based on a 14-day running average with a simultaneous 5-day running average within 25 percent of the applicable 14-day OMR flow requirement. Depending on the extant conditions, the SWG shall make recommendations for the specific OMR flows within this range from the onset of implementing RPA Component 2 through its termination. The Service shall make the final determination regarding specific OMR flows. This action shall end June 30 or when the 3-day mean water temperature at Clifton Court Forebay reaches 25° C, whichever occurs earlier.

The Spring HORB shall be installed only if the Service determines delta smelt entrainment is not a concern (Action 5 from Attachment B).

RPA Component 3: Improve Habitat for Delta Smelt Growth and Rearing

The objective of this component is to improve fall habitat for delta smelt through increasing Delta outflow during fall. Increase in fall habitat quality and quantity will both benefit delta smelt.

Subject to adaptive management as described below and in Action 4 in Attachment B, during September and October in years when the preceeding precipitation and runoff period was wet or above normal as defined by the Sacramento Basin 40-30-30 index, Reclamation and DWR shall provide sufficient Delta outflow to maintain monthly average X2 no greater (more eastward) than 74 km (from the Golden Gate) in Wet WYs and 81 km in Above Normal WYs. The monthly X2 target will be separately achieved for the months of September and October. During any November when the preceding

water year was wet or above normal as defined by the Sacramento Basin 40-30-30 index, all inflow into CVP/SWP reservoirs in the Sacramento Basin shall be added to reservoir releases in November to provide an additional increment of outflow from the Delta to augment Delta outflow up to the fall X2 of 74 km for Wet WYs or 81 km for Above Normal WYs, respectively. In the event there is an increase in storage during any November this action applies, the increase in reservoir storage shall be released in December to augment the December outflow requirements in SWRCB D-1641.

Given the nature of this Action and to align its management more closely with the general plan described by the independent review team and developed by Walters (1997), the Service shall oversee and direct the implementation of a formal adaptive management process. The adaptive management process shall include the elements as described in Attachment B. This adaptive management program shall be reviewed and approved by the Service in addition to other studies that are required for delta smelt. In accordance with the adaptive management plan, the Service will review new scientific information when provided and may make changes to the action when the best available scientific information warrants. For example, there may be other ways to achieve the biological goals of this action, such as a Delta outflow target, that will be evaluated as part of the study. This action may be modified by the Service consistent with the intention of this action based on information provided by the adaptive management program in consideration of the needs of other listed species. Other CVP/SWP obligations may also be considered.

The adaptive management program shall have specific implementation deadlines. The creation of the delta smelt habitat study group, initial habitat conceptual model review, formulation of performance measures, implementation of performance evaluation, and peer review of the performance measures and evaluation that are described in steps (1) through (3) of Attachment B shall be completed before September 2009. Additional studies addressing elements of the habitat conceptual model shall be formulated as soon as possible, promptly implemented, and reported as soon as complete.

The Service shall conduct a comprehensive review of the outcomes of the Action and the effectiveness of the adaptive management program ten years from the signing of the biological opinion, or sooner if circumstances warrant. This review shall entail an independent peer review of the Action. The purposes of the review shall be to evaluate the overall benefits of the Action and to evaluate the effectiveness of the adaptive management program. At the end of 10 years or sooner, this action, based on the peer review and Service determination as to its efficacy shall either be continued, modified or terminated.

RPA Component 4: Habitat Restoration

This component of the RPA (Action 6 of Attachment B) is intended to provide benefits to delta smelt habitat to supplement the benefits resulting from the flow actions described above. DWR shall implement a program to create or restore a minimum of 8,000 acres of intertidal and associated subtidal habitat in the Delta and Suisun Marsh. These actions

may require separate ESA consultations for their effects on federally listed species. The restoration efforts shall begin within 12 months of signature of this biological opinion and be completed by DWR (the applicant) within 10 years. The restoration sites and plans shall be reviewed and approved by the Service and be appropriate to improve habitat conditions for delta smelt. Management plans shall be developed for each restoration site with an endowment or other secure financial assurance and easement in place held by a third-party or DFG and approved by the Service. The endowment or other secure financial assurance shall be sufficient to fund the monitoring effort and operation and maintenance of the restoration site.

An overall monitoring program shall be developed to focus on the effectiveness of the restoration actions and provided to the Service for review within six months of signature of this biological opinion. The applicant shall finalize the establishment of the funding for the restoration plan within 120 days of final approval of the restoration program by the Service. There is a separate planning effort in Suisun Marsh where the Service is a co-lead with Reclamation on preparation of an Environmental Impact Statement. Restoration actions in Suisun Marsh shall be based on the Suisun Marsh Plan that is currently under development.

RPA Component 5: Monitoring and Reporting

Reclamation and DWR shall ensure that information is gathered and reported to ensure:

- 1) proper implementation of these actions,
- 2) that the physical results of these actions are achieved, and
- 3) that information is gathered to evaluate the effectiveness of these actions on the targeted life stages of delta smelt so that the actions can be refined, if needed.

Essential information to evaluate these actions (and the Incidental Take Statement) includes sampling of the FMWT, Spring Kodiak Trawl, 20-mm Survey, TNS and the Environmental Monitoring Program of the IEP. This information shall be provided to the Service within 14 days of collection. Additional monitoring and research will likely be required, as defined by the adaptive management process.

Information on salvage at Banks and Jones is both an essential trigger for some of these actions and an important performance measure of their effectiveness. In addition, information on OMR flows and concurrent measures of delta smelt distribution and salvage are essential to ensure that actions are implemented effectively. Such information shall be included in an annual report for the WY (October 1 to September 30) to the Service, provided no later than October 15 of each year, starting in 2010.

Reclamation shall implement the RPA based on performance standards, monitoring and evaluation of results from the actions undertaken and adaptive management as described in RPA component 3. RPA component 3 has a robust adaptive management component that requires a separate analysis apart from those required under this component. Some of the data needed for these performance measures are already being collected such as the FMWT abundances and salvage patterns. However, more information on the effect of

these actions on smelt survival and the interactions of project operations with other stressors on delta smelt health, fecundity and survival is needed. This information may provide justification for refining these actions to better address the needs of delta smelt. Studies like those of the IEP's POD workteam have provided much useful information on the needs of delta smelt and the stressors affecting them that was integral in the development of these actions.

Avoidance of Jeopardy and Adverse Modification

The conservation needs of the delta smelt at this time are primarily associated with: (1) protective measures for pre-spawning adult delta smelt; (2) improvement of flow conditions in the Central and South Delta so that larval and juvenile delta smelt can successfully rear and move downstream with a minimum entrainment risk; and (3) restoration and enhancement of habitat availability and quality that improves growth and survival of delta smelt.

The RPA components described above and in Attachment B specifically address the above factors to the extent provided by the regulatory criteria that define a RPA. Implementation of this RPA will increase the likelihood that delta smelt habitat conditions and attributes for migration, spawning, recruitment, growth, and survival will be provided during the term of the proposed action. For these reasons, the Service finds that implementation of the RPA described above is likely to avoid jeopardy to the delta smelt and adverse modification of its critical habitat.

Incidental Take Statement

Introduction

Section 9 of the Act and Federal regulations pursuant to section 4(d) of the Act prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harass is defined by the Service as an intentional or negligent act or omission which creates the likelihood of injury to a listed species by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding or sheltering. Harm is defined by the Service to include significant habitat modification or degradation that results in death or injury to listed species by impairing behavioral patterns including breeding, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be a prohibited taking under the Act, provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

ACTION 6: HABITAT RESTORATION

Objective: To improve habitat conditions for delta smelt by enhancing food production and availability.

Action: A program to create or restore a minimum of 8,000 acres of intertidal and associated subtidal habitat in the Delta and Suisun Marsh shall be implemented. A monitoring program shall be developed to focus on the effectiveness of the restoration program.

Timing: The restoration efforts shall begin within 12 months of signature of this biological opinion and be completed within a 10 year period.

Background

The historic Delta was a tidal wetland-floodplain system including about 350,000 acres of tidal wetland. Almost all of the historic wetlands in the Delta have been lost due to conversion to agriculture and urban development. The Delta currently supports less than 10,000 acres of tidal wetland, all of which is small and fragmented. This conversion of the Delta's wetlands beginning in the mid-nineteenth century has resulted in a landscape dominated by agricultural lands intersected by deep and comparatively uniform tidal channels.

Delta smelt feed mainly on zooplankton throughout their life cycle (Nobriga and Herbold 2008) with the copepod *Pseudodiaptomus forbesi* being the dominant prey item for juvenile delta smelt in the summer (Lott 1998; Nobriga 2002; Hobbs et al. 2006). Diatoms form the base of the pelagic foodweb and primary consumers (e.g. copepods) appear to be food-limited in the Delta and Suisun (Muller-Solger et al. 2002; Sobczak et al. 2002). Pelagic productivity in the Delta and Suisun Bay has been declining for several decades with a steep decline following the introduction of the overbite clam in 1986 (Kimmerer and Orsi 1996). Histopathological evaluations have provided evidence that delta smelt have been food-limited during the summer months (Bennett 2005). This finding has been corroborated by recent work on juvenile delta smelt as part of ongoing studies on the POD. Moreover, recent studies suggest a statistical association between delta smelt survival and the biomass of copepods in the estuary (Kimmerer 2008).

Overall research in other estuaries has indicated that tidal wetlands are highly productive. Although definitive studies have not been done on the type and amount of productivity in freshwater tidal wetlands of the Delta, brackish tidal wetlands of Suisun Marsh are one of the most productive habitats in northern San Francisco Bay-Delta estuary (Sobczak et al. 2002). It is likely that restored freshwater tidal wetlands in the Delta would have higher productivity than the brackish wetlands of Suisun (Odum 1988). A large portion of the production in Suisun Marsh consists of high quality phytoplankton-derived carbon (Sobczak et al. 2002) that is an important food source for zooplankton and therefore can contribute to the base of the pelagic foodweb. Modeling suggests that the tidal wetlands of Suisun currently provide about 6 percent of the organic carbon to the pelagic habitats of Suisun Bay (Jassby et al. 1993). In addition, sampling in Liberty Island shows that these freshwater tidal habitats can be a source of high-quality phytoplankton that contribute to the pelagic food web downstream (Lehman et al. 2008). Thus, restoration of large amounts of intertidal habitat in the Delta and Suisun could enhance the ecosystem's pelagic productivity.

Justification:

Since it was introduced into the estuary in 1988, the zooplankton *Pseudodiaptomus forbesi* has been the dominant summertime prey for delta smelt (Lott 1998; Nobriga 2002; Hobbs et al. 2006). There is evidence suggesting that the co-occurrence of delta smelt and *Pseudodiaptomus forbesi* has a strong influence on the survival of young delta smelt from summer to fall (Miller 2007). The Effects Section indicates that

Pseudodiaptomus distribution may be vulnerable to effects of export facilities operations and therefore, the projects have a likely effect on the food supply available to delta smelt.

The near complete loss of tidal wetlands from the Delta threatens the persistence of delta smelt by reducing productivity at the base of the pelagic foodweb. Primary production in tidal wetlands of the Northern San Francisco estuary has been shown to support high zooplankton growth (Muller-Solger et al. 2002). This action should therefore enhance the foodweb on which delta smelt depend. This action is designed to increase high quality primary and secondary production in the Delta and Suisun Marsh through an increase in tidal wetlands. Exchange of water between the tidal wetlands and surrounding channels should distribute primary and secondary production from the wetlands to adjacent pelagic habitats where delta smelt occur. This exchange should be optimized through intertidal habitat restoration designed to incorporate extensive tidal channels supported an appropriately sized vegetated marsh plain which will provide the necessary tidal prism to maintain large tidal exchange.

New evidence indicates how tidal marsh may benefit delta smelt even if they do not occur extensively within the marsh itself. Specifically, monitoring suggests this species is taking advantage of recently-created tidal marsh and open water habitat in Liberty Island. The fact that delta smelt make heavy use of habitat in the Cache Slough complex has been evident in sampling by the DFG's Spring Kodiak trawl and 20 mm surveys (www.delta.dfg.ca.gov). The Spring Kodiak trawls show that delta smelt are present in channels of the Cache Slough complex during winter and spring; the collection of larval delta smelt in subsequent 20-mm surveys indicates that these adult delta smelt eventually spawn in the vicinity. In addition, the use of Cache Slough complex by delta smelt includes habitat on Liberty Island. The island flooded in 1998 and has evolved rapidly into a system of open-water and tidal marsh habitat. Recent sampling of Liberty Island by USFWS biologists (<http://www.delta.dfg.ca.gov/jfmp/libertyisland.asp>) revealed that delta smelt both spawn and rear in Liberty Island. Light traps collected relatively high numbers of larval delta smelt in several locations of Liberty Island during the 2003 spawning period for this species. Moreover, subsequent beach seine sampling showed that older delta smelt were present at all ten of their sampling stations during 2002-2004 and in all seasons of the year (USFWS, unpublished data). These results are particularly striking because they were from a period when delta smelt was at record low abundance. Collection of delta smelt from shallow inshore areas using seines indicates that the fish do not occupy deeper pelagic habitat exclusively. These results seem reasonable in light of the area's consistently high turbidity (Nobriga et al. 2005; DWR, unpublished data) and zooplankton abundance (e.g. Sommer et al. 2004), both of which are important habitat characteristics for delta smelt (Bennett 2005; Feyrer et al. 2007). In any case, these data suggest that freshwater tidal wetlands can be an important habitat type to delta smelt with proper design and location.

A monitoring program shall be developed to focus on the effectiveness of the restoration program. This program shall be reviewed and modified as new information becomes available.

U.S. Fish and Wildlife Service Staff BDCP Progress Assessment

In April 2012, the Fish and Wildlife Service (FWS) submitted our “red flag” comments regarding the previous draft of the Bay Delta Conservation Plan (BDCP). These comments were developed by agency staff to identify those issues that may require significant changes to the BDCP and would need to be resolved prior to formal submittal of the draft plan. Since then, FWS has worked closely with the State and its consultants on the details of the revised BDCP. The following is a staff re-assessment of the materials provided to FWS in the December 2012 Administrative Draft BDCP document and Section 5.5, which was submitted to FWS in February 2013. Additional draft materials were subsequently submitted to FWS on March 1st. We have conducted an initial review of the March 1st materials to confirm that all of the following comments are still applicable, but because of the large size of the BDCP and our desire to provide this review in a timely fashion there may be issues with the March materials that we have not fully sorted out yet.

We would like to acknowledge the very significant improvements and progress that have been made in the development of the effects analysis and the plan itself over the past year. DWR has substantially amended the proposed plan by reducing the number of planned intakes and overall capacity, and the new project description includes a set of operating criteria (called the “high outflow scenario” in the BDCP) developed with FWS advice that improves on the historical baseline flows. The changes in the “high outflow” operating criteria are in direct response to our previous comments and are critically important to providing for covered species needs.

Goals and objectives are another area where the BDCP has made a great deal of progress. The draft is not perfect, and we note below that a few very important fixes are needed, but in general the goals and objectives articulated in the plan are conceptually sound and appropriate for an HCP of this magnitude and proposed duration. Goals and objectives are the foundation on which the BDCP must be built, so the cooperative progress that has brought them to their current state is very significant.

Our staff have experienced excellent cooperation and coordination with the project consultants (ICF International) along with the other planning agencies. There has been significant improvement in the expanded analytical methodologies used in the effects analysis, and many technical and policy issues have been resolved or partly resolved. Many other technical and plan component issues are currently in active discussion, and we are optimistic they can be resolved with additional time, technical resources, and independent peer review. We look forward to continuing our close collaboration with all of the involved parties to resolve remaining issues and complete this planning process.

This document is an update to the “red flags” document we provided to DWR in April 2012. The first section provides an assessment of the progress that has been made in addressing the April 2012 FWS “red flags,” and reflects our review of the December 2012 draft BDCP document, which in many cases was also informed by the Delta Science Program Independent Panel (DSP IP) review last summer. We have numbered the issues and, where appropriate, edited the update to reflect our initial review of the March 2013 BDCP. The format below shows our comments from last April *in italics*, followed by our updated assessment of these issues. We made a few very minor edits to the original comments for clarity. Because our review has been informed by the Delta Science Program independent panel’s “phase II review” findings, we have also commented on the degree to which the current BDCP is responsive to the panel’s recommendations.

The second section of this document describes several new comments and issues resulting from our review of the current draft of the BDCP (the December 2012/February 2013 version of the document or Admin Draft). These new major concerns highlight key areas of the BDCP that will need to be addressed between now and the time the plan and accompanying materials are submitted to us as a complete application under section 10 of the ESA. We have provided, where possible, suggestions for addressing these comments and are committed to working closely with our State and Federal partners to find resolutions to these issues. We view these comments as critical to the completion of a successful planning effort and generally they should be viewed as very important for resolution, preferably prior to issuance of the public draft.

We are providing detailed technical comments and edits in “track changes” format for several chapters of the BDCP directly to the State and its consultants. We did not provide “track changes” edits to sections 3.4 (decision tree element), 3.6, 6.4, or 7.3.4, each of which is the subject of a comment in this document. We believe it would be more efficient to discuss resolution of issues in those sections with our partners as we move ahead.

In summary, we note very substantial progress has been made, and we look forward to continue to work collaboratively with all parties towards timely completion of this ambitious plan.

PART I: UPDATE TO “RED FLAGS” DOCUMENT

Issue Area 1: Incomplete conceptual foundation for the Effects Analysis

1.1. The effects analysis deals with the critical concept of uncertainty inconsistently and does not effectively integrate, use, and report uncertainty in the Net Effects.

Original comment: *The BDCP Independent Science Advisors, the National Research Council review panel, the Delta Science Program panel, and we have all commented on the inherent uncertainty in the scientific understanding of certain aspects of the*

April 3, 2013

Bay-Delta ecosystem. This extends to difficulty predicting how the ecosystem might respond to BDCP implementation. Uncertainty needs to be used objectively and consistently, and the appendices and Net Effects need to develop and propagate uncertainty through the threads of the effects analysis. Highly important variation in the value and uncertainty of individual conservation measure features will occur over space and time as a function of implementation strategy and other factors. Many of the current conservation measures and issues are, or appear to be, overly simplified or otherwise superficially analyzed. The list includes OMR management, fish-habitat relationships, the habitat-for-flow trade-off, predator suppression, nuisance vegetation suppression, and others. Each of the foregoing issues raises uncertainties that propagate through the threads of analysis and must be reckoned within the "net" conclusions. To the extent we can form our own conclusions about the Net Effects without having access to all the revised documents, it appears that inconsistency in dealing with uncertainty has resulted in conclusions that overly optimistically predict Preliminary Project benefits for almost all of the target fish species almost everywhere. As such, we are reluctant to rely on the conclusions of the present effects analysis. We await receipt of the outstanding appendices, and look forward to working closely with our partners to provide technical assistance as these matters are resolved.

March 2013 Update: The revised documents have improved treatment of uncertainty in some areas, but this comment remains a critical issue. The assessment of restoration effects remains incomplete and optimistic, as we describe as a separate issue. Elsewhere, most of the treatment of uncertainty remains informal and qualitative, including descriptions of alternative hypotheses, sentences stating the degree of uncertainty where professional judgment is relied upon for the Net Effects, etc. The Service thinks the following additional specific changes should be incorporated to better address uncertainty in the EA:

1. We are satisfied with the structure and general approach of the HSI-related analysis, but deployment of the model is restricted in scope and represents only one possible choice of input values. In order to more fully explore the possible range of outcomes, additional input value choices should be (including minimum, median, and maximum values – in addition to those values included until now). In other words, the HSI procedure should be repeated with less (and more) optimistic estimates of restoration/creation performance (similar to the fall X2 analysis in Appendix 5C). Note: the GAM analyses that underlie some of the predicted delta smelt responses to habitat gradients were already "liberal" in that they used presence-absence instead of density (Kimmerer et al. 2009). Therefore, approximations to these curves for the HSI should not extend outside the GAM data because doing so generates a modeled species response that is inconsistent with the actual trawl data.
2. The HSI-based analysis does not appropriately allow for habitat restoration to have net negative effect on covered fish species, which is a possible outcome. The HSI-based approach rates outcomes on a scale from 0 to 1. In the context of the "net effects," this means that no project or CM will ever be detrimental; the worst case is no effect. Given uncertainties about the paths and outcomes of restoration and

habitat creation, the analysis should acknowledge that some projects might be detrimental to the overall outcome (see comments, below, regarding unintentional deep-water habitat creation like Franks Tract and Mildred Island). Additionally, where variability could be introduced into the HSI analysis we sometimes find the estimates to be biased upward in favor of habitat restoration success in the future (for example, the HSI-estimated egg-larvae life stage suitability curve using the GAM-based method is up to 50% more optimistic than the sample-based data would suggest it should be – see Figure E.4-4).

3. Use of a more sophisticated splittail Habitat Suitability Index; the current one only uses depth as a determinant of splittail habitat suitability. We do not find the argument compelling. Splittail migrate to different habitats to complete different parts of their life cycle, so there must be additional factors that define habitat suitability for fish of different ages. There is information on splittail temperature limits, salinity distributions, seasonal timing of occupancy of particular regions, etc. in the literature.
4. The Net Effects summary graphs should include “uncertainty bars” that are larger when uncertainty is higher and smaller when uncertainty is lower so that both expected magnitude and confidence in the conclusion are simultaneously conveyed. The Delta Science Program independent panel’s 2012 report suggested some ways to approach this.

We have also provided extensive track change edits and bubble comments in both Chapters 3 and 5 that we think will improve the document further and provide a basis for discussions to resolve these issues. Adoption of these recommendations will help the EA better respond to Recommendation 13 of the June 2012 DSP Review Panel.

1.2. A key missing piece from the Analytical Framework document is how the Effects Analysis will be framed in the context of fish population dynamics.

Original comment: *We expected this to occur in the draft Technical Appendix on the subject of fish populations, but that document did not fully analyze long-term and recent population trends in the target fishes. There is clear evidence that most of the covered fish species have been trending downward. The document should clearly and accurately lay out what is known of the foundations of each species’ population dynamics (e.g., density-dependent under some circumstances?, trends in carrying capacity?, etc.) as mechanistically as possible and discuss how BDCP actions will influence these processes. Because the conceptual foundations presented to date do not frame the effects in the context of historical and present-day fish population dynamics and the most parsimonious explanations of their causes, it is unclear how the net effects should be interpreted. We await receipt of the life cycle modeling appendix to complete our review of this issue, and look forward to continuing to work with our partners to help ensure that the best available science is used in the effects analysis.*

March 2013 Update: Chapter 5 has made some improvements in its depiction and use of fish population dynamics, but this remains a critical issue. One example is the use of the longfin smelt model provided to ICF by USFWS last fall. The track changes edit of the Fish

April 3, 2013

Life Cycle Models Appendix 5G pdf provided by ICF seems to have entirely edited out the descriptions of the Maunder and Deriso (2011) and Miller et al. (2012) statistical life cycle models. We want to clarify that we did not ask for such a change to be made and do not think it is necessary or appropriate to strike descriptions of these analyses from the supporting materials for Chapter 5.

We will use this opportunity to clarify that the IEP monitoring program has decades of relative abundance data for covered fish species – some examples of which are summarized in Table 2A.1-1. These data sets are the bases for the Maunder and Deriso and Miller et al. analyses, as well as all other population assessments that have preceded them. The Service thinks the following additional specific changes should be incorporated, preferably into Appendix 5G, and then used to provide an objective foundation for the Net Effects:

1. 20 mm, Summer Townet Survey, Fall Midwater Trawl, Spring Kodiak Trawl, and Suisun Marsh abundance indices for delta smelt
2. Normalized salvage density time series for delta smelt
3. Scatterplots showing the relationships among these indices
4. Description of what is implied by these relationships and objective summaries of the factors that the following authors have explored to explain them (Stevens and Miller 1983; Jassby et al. 1995; Kimmerer 2002; Bennett 2005; Kimmerer et al. 2009; Mac Nally et al. 2010; Thomson et al. 2010; Maunder and Deriso 2011; Miller et al. 2012)
5. 20mm, Fall Midwater Trawl, Bay Study Midwater Trawl, Bay Study Otter Trawl, Spring Kodiak Trawl, and Suisun Marsh abundance indices for longfin smelt
6. Normalized salvage density time series for longfin smelt
7. Scatterplots showing the relationships among these indices
8. Description of what is implied by these relationships and objective summaries of the factors that the following authors have explored to explain them (Stevens and Miller 1983; Jassby et al. 1995; Kimmerer 2002; Rosenfield and Baxter 2007; Kimmerer et al. 2009; Mac Nally et al. 2010; Thomson et al. 2010)
9. Fall Midwater Trawl, Suisun Marsh, Chipps Island, and USFWS Beach Seine abundance indices for splittail
10. Salvage density time series for age-0 and age-1 and older splittail – *these should not be normalized as they are an abundance index of themselves*
11. Scatterplots showing the relationships among these indices
12. Description of what is implied by these relationships and objective summaries of the factors that the following authors have explored to explain them (Meng and Moyle 1995; Sommer et al. 1997; Kimmerer 2002; Moyle et al. 2004; Feyrer et al. 2006; Kimmerer et al. 2009).

These fixes will broadly help to address the 2012 independent panel review recommendations, including 1, 3, 5, 10, 13, and 15. These fixes would also provide the Service with the basic status and population dynamic trends for the covered species which we need to include in permit documents.

Issue Area 2: Inadequate conceptual models and analysis of

estuarine fish habitat, and consequent project issues

2.1. The objectives for restoring habitat addressed in the Chapter 5's Restoration Appendix are simply described, but it is not clear whether the plan will or can achieve them.

Original comment: The draft Appendix E states that BDCP's habitat restoration has two objectives¹. The first is to "increase the amount of available habitat for covered fish species." This first objective is reasonable, but does not clearly articulate that new habitat needs to be good quality habitat. We know quite a bit about what determines habitat value to covered fish species. This knowledge is partly reflected in the habitat suitability indices that are currently under development, but is often discounted elsewhere in the Chapter 5 documents. The habitat for BDCP target fishes, and all estuarine fishes for that matter, is fundamentally created by the interaction of tidal and river channel flows with the broader estuary landscape. The Preliminary Project proposes to extract larger volumes of fresh water from the Delta than are currently exported against a backdrop of rising sea level and a re-design of the estuary landscape that will change tidal flows. Whether this can be accomplished while other parts of the plan simultaneously contribute to recovery of covered species is an unanswered question of central importance. Fully incorporating existing science on the interplay of freshwater flow and the Plan Area landscape and its constituent species would provide more accurate and defensible conceptual models for the Effects Analysis. We also suggest consulting the Department of Interior Adaptive Management Technical Guide and other adaptive management resources on the role of (potentially conflicting or alternative) conceptual models in the adaptive management process. We look forward to working with our partners and providing technical assistance toward the resolution of this issue.

The second objective is "to enhance the ecological function of the Delta." This formulation is not clear. The Delta provides multiple ecological services, and alterations to different parts of the Delta may potentially contribute to them in different ways. There have been several large-scale, unintentional or quasi-intentional "wetland restoration projects" in the Bay-Delta since 1920. These include Franks Tract in the 1930s, Mildred Island in the early 1980s, Liberty Island in the latter 1990s, and Napa River marsh in the past decade to name a few. There is also the seasonal fish habitat generated by large-scale floodplain restoration along the lower Cosumnes River that started in the mid-1990s. The draft appendix never mentions these events or synthesizes what is known about them. This is a critical aspect of the analysis, and needs to be done credibly. We believe these "unintended experiments" provide useful lessons in what we may expect from actions on similar spatial scales in similar circumstances in various restoration scenarios.

A close look at the estimated elevations of restored habitats shows that much of the acreage is not at intertidal elevation and thus will not readily produce the dendritic channel mosaics on a tidal marsh plain that are frequently espoused in the appendix for their fish production

¹ We note that these objectives are more akin to goals. They are not at present specific enough to function as objectives in the context of performance evaluation or adaptive management.

April 3, 2013

benefits. Particularly by the late long-term, there is a lot of the subtidal habitat types in the model outputs². We do not know if unintentional habitat restorations that have occurred have increased the productivity of the Delta beyond what it would have been without them. In a pure carbon-productivity sense they might have – because productivity is just creation of biological carbon per unit of time. However, these and other “wetland restorations” have not noticeably increased the capacity of the Delta to produce larger populations of BDCP-covered native fishes. As achieving this is a key premise of the BDCP, understanding these examples and learning from what has happened in each case is a matter of great importance. We look forward to providing assistance to our partners as these comments are addressed.

March 2013 Update: The BDCP has benefited from the addition of a version of operations (the “high outflow scenario”) that includes improved Delta outflow during the spring and fall months to benefit delta smelt, longfin smelt, green sturgeon, and other species. The Service worked with DWR on this version of operations and believe it would provide better conservation outcomes for covered fish species than the other three versions presented in the project description. With regard to off-channel habitat restoration, the revised Chapter 5.5 has improved regarding its acknowledgement about the uncertainty in landscape restoration; however, critical issues in the original critique that are central to the success of the BDCP remain inadequately addressed.

Scientific literature cited in the plan, new analyses provided by DWR, and conclusions of the independent scientific review panel have reinforced our concern that the BDCP restoration plan has not been carefully thought out and has uncertain prospects for benefiting native aquatic estuarine species, particularly delta smelt and longfin smelt.

Given the occurrence and apparently favorable growth rates of delta smelt occupying the Cache Slough complex, the Service expects benefits from the creation of new open intertidal and tidally flushed habitat in that region. However, we are concerned about the effects of marsh creation in other areas, and about the net effect of the restoration proposal as a whole, given its large spatial scale.

(1) It is unclear how much food production will be available for export from new tidal marsh areas, because the percentage capture of that production into benthos by exotic bivalves that are likely to infest newly restored areas is hard to predict and might be high (Lucas and Thompson 2012). Since we expect that the benefit of these new marsh areas to the smelts would arise from export of plankton into river channels, benefits of new habitat might not scale up in proportion to the geographical area of new marshes if those marshes evolve in a way that is particularly adverse to plankton production and export processes.

² It may be possible to manage subsided lands to encourage natural processes to raise them back to sea-level so that they can support self-sustaining intertidal marshes. However, that process can be very slow and the full realization of potential physical morphology could extend far beyond the 50-year proposed term of the BDCP.

April 3, 2013

(2) New modeling presented to a BDCP audience on March 5th, 2013 by John De George of RMA, and informal comments by USGS staff to us, suggest that tidal energy will be strongly limiting in BDCP tidal marsh restoration, with the available tidal prism spread over a much larger area by the late long-term if the proposed acreages are fully implemented. The attenuation of tidal exchange in individual restoration areas might tend to reduce the export of plankton and reduce turbidity; both of these effects would increase with the total area of newly created marsh, and might tend to reduce the value of early restoration areas as new ones are added elsewhere.

(3) The effects analysis acknowledges that a portion of the Sacramento River sediment supply will be diverted at the North Delta intakes, and that that diversion might be detrimental to native fishes, estimating the average effect to be minus 8-9% of sediment. It is hard to draw definitive conclusions about the ultimate effect of this change, but an average loss of 8-9% of the sediment supply that would ordinarily pass into the Delta and Suisun Bay likely implies higher average water clarity throughout the year. Besides potentially negative effects on delta smelt and longfin smelt and their habitat, which benefit from turbid water, clearer water would encourage growth of exotic aquatic plants and related effects in many areas of the North and West Delta.

(4) The independent science panel review recommended caution and thorough planning with respect to restoration activities (recommendation #6). It said, in part:

Considerable uncertainty exists, however, about the likelihood of one of the co-equal goals, i.e., the conservation of the Bay-Delta system. Among the principal issues are the sequencing and scale of the implementation of the planned conservation measures. The Plan recommends a large number of conservation measures, but provides no explanation as to how and when they would be implemented, what the particular sequence would be and the intervals between implementation of conservation measures. The Plan also proposes to increase restored tidal and other habitats at a large scale. In terms of general approaches, large-scale efforts at protection and restoration are theoretically positive but on-the-ground implementation can be difficult and is fraught with uncertainty. (Panel report, pp. 18-19)

The panel proposed specific fixes in several areas (page 19). The new draft effects analysis addresses some of these fixes, but in our view further follow-up is needed on these issues to clarify what the BDCP intends to do to fill the gaps identified by the panel. The plan's ultimate conclusions regarding the outcome of creating such large new areas of tidal marsh remain more positive and certain than the literature and scientific authorities suggest they should be.

(5) We were disappointed not to see the in-depth evaluation of unintentional wetland "restoration experiments" that we requested last spring. We continue to advise our partners that this is a necessary analysis. Key references for Bay-Delta shallow water habitat issues and fish food include: Turner and Kelley 1966; Meng et al. 1994; Aasen 1999; Meng and Matern 2001; Matern et al. 2002; Lucas et al. 2002; Reed 2002; Sommer et al. 2002; Mueller-Solger et al. 2002; Brown 2003; Feyrer and Healey 2003; Feyrer et al. 2003;

April 3, 2013

[Crain et al. 2004; Feyrer 2004; Grimaldo et al. 2004 *in* Feyrer et al. 2004]; Sommer et al. 2004; Dean et al. 2005; Feyrer et al. 2005; Nobriga et al. 2005; Wright and Schoellhamer 2005; Brown and May 2006; Grosholz and Gallo 2006; Hobbs et al. 2006; Lopez et al. 2006; Brown and Michniuk 2007; Feyrer et al. 2007 [2 splittail papers in TAFS]; Cloern 2007; Cohen and Bollens 2008; Hestir et al. 2008; Lehman et al. 2008; [RL] Miller et al. 2008; Moyle 2008; McLain and Castillo 2009; Lehman et al. 2010 [Liberty Island]; Moyle et al. 2010; Howe and Simenstad 2011; Santos et al. 2011; Gewant and Bollens 2012; Grimaldo et al. 2012; Lucas and Thompson 2012; Greenfield et al. 2013. There is also a substantial relevant literature from other systems.

Many of these papers are cited in the draft BDCP documentation, but the analysis is not incisive. We certainly agree that there is considerable uncertainty regarding wetland restoration performance in the estuary (see above); however, as this extensive list of publications implies, there is already a lot that has been learned that can help distinguish potentially “good” restoration approaches from very likely “bad” ones, particularly in terms of the consequences to native fishes. The additional insight would help calibrate the BDCP net effects, or at least provide an additional, objective window into the realism of its conclusions. These authors also provide key analyses of wetland function and species occupancy that can inform relatively detailed conceptual models. We can provide ICF with copies of these papers if necessary.

The Service also recommends the following specific changes:

- i. The documents accurately characterize delta smelt spawning habitat in descriptions of the species biology, but the Chapter 3 conservation measures and the Chapter 5 Habitat Suitability Indices and Net Effects make unsupportable or ambiguous linkages between habitat restoration and likely spawning habitat. Fix: Incorporate red line strikeout edits and either (1) show through modeling what subset of “tidal habitat restoration” will have sandy beaches with a turbid, active overlying water column, or (2) avoid the speculation that habitat restoration will create spawning habitat and the speculation that spawning habitat is limiting delta smelt recruitment.
- ii. The documents accurately characterize longfin smelt spawning habitat in descriptions of the species biology, but the Chapter 3 conservation measures and the Chapter 5.5 Net Effects make unsupportable or ambiguous linkages between habitat restoration and likely spawning habitat. Fix: Incorporate red line strikeout edits and either (1) show through modeling what subset of “tidal habitat restoration” will have sandy beaches with a turbid, active overlying water column, or (2) avoid the speculation that habitat restoration will create spawning habitat and the speculation that spawning habitat is limiting recruitment. The stressor reduction target for longfin smelt spawning habitat proposes as a target, a condition that already occurs currently. “Increase overlap of suitable spawning substrate, flow, salinity, and water temperature in the lower Sacramento and lower San Joaquin Rivers such that spawning, as indicated by the presence of early larval

longfin smelt in DFG larval smelt surveys, occurs in at least three of the following locations in all years: Lower Sacramento, Cache Slough ROA, Lower San Joaquin, Suisun Bay, and Suisun Marsh ROA. Increasing the extent of suitable spawning habitat for longfin smelt will contribute to an increase in spawning success, thereby contributing to an increase in juvenile and, over-time, adult longfin smelt abundance." Thus, as written this target is already achieved. Fix: first, acknowledge that spring Delta outflow is a well-established driver of longfin smelt abundance, and formulate a stressor reduction target that provides spring Delta outflow in accordance with the Service's standing recommendation. Second, provide a plausible prediction of marginal longfin smelt benefits that will be realized by enhancing extent of spawning habitat or delete the corresponding stressor reduction target.

- iii. It is possible that increases in QWEST associated with CM1 and SAV removal associated with CM13 might (jointly) lead to higher spawning success of both smelt species in the mainstem of the San Joaquin River where some spawning is thought to occur presently; we have suggested revisions that can articulate this potential benefit and should be considered when the adaptive management plan for these actions is developed.
- iv. The current state of science regarding splittail spawning habitats is misapplied; splittail are not known to spawn in tidal environments. Fix: Do not claim that any BDCP action other than CM2 will provide spawning habitat for splittail.
- v. Chapter 3.3 issue: CM18 (Conservation hatchery) is linked to wild population goals and objectives for delta and longfin smelts. This is inappropriate and contrary to the Service's present policy for these species. Fix: CM18 will need new objectives designed specifically for it.

As we have tried to make clear in this update, the uncertainties associated with restoration are of such importance that the success of the BDCP as a Delta conservation effort may hinge on the realism of plan expectations and effectiveness of the BDCP adaptive management program. Moreover, these uncertainties must be viewed as uncertainties for water operations, which are also a driver of covered aquatic species abundances. The effects analysis should more clearly acknowledge these uncertainties to motivate the intensive further study that will be required. The State should not assume the habitat restoration components of the plan will succeed in full, because they may not. We endorse NMFS's recommendation that alternative plausible levels of success for habitat restoration be evaluated in the effects analysis. The BDCP will have to jointly adaptively manage both restoration and water operations to have the best chance of favorable conservation outcomes for covered species and their habitats.

The Service is providing numerous track change edits and bubble comments that we think will improve the document further. If any track-changes comment appears to conflict with the written comments above, the written comments take precedence.

April 3, 2013

Addressing the Service's concerns described above should also improve the BDCP's responsiveness to Recommendations 1, 2, 5, 6, 8, and 16 in the June 2012 DSP Review Panel report.

We look forward to working with DWR and our other partners to resolve these issues.

2.2. The modeling shows a gain of shallow, intertidal habitats in the Plan Area by the early long-term, which is a goal of the BDCP. However, it also shows that there is a net loss of intertidal habitat and a large increase in deep water habitat by the late long-term.

Original comment: *The Bay-Delta is not currently limited in terms of deep water habitats, and some relevant historical experience suggests deeper off-channel habitats are likely to be more favorable habitat to exotic species than to natives, so an increase in the depth of restored habitats does not appear to be a desirable outcome. Thus the benefits attributed to creating the proposed habitat acreages may be quite optimistic. We look forward to providing technical assistance on this issue; a good start would be a more in-depth investigation of the expected depth distribution in potentially restored areas in the early and late long-term time periods.*

March 2013 Update: This is a resolved issue.

2.3. The effects analysis underemphasizes Bay-Delta water flows as a system-wide driver of ecosystem services to the San Francisco Estuary.

Original comment: *While climate and associated hydrology affect the magnitude of watershed runoff, system hydrodynamics downstream of the big dams (e.g., exports, OMR flows, X2, gate operations, etc.) are largely driven by coordinated water operations. All of these influence the habitats and population dynamics of listed species. It is critical that the BDCP effects analysis identify changes in operations that will importantly alter hydrodynamics, and address in depth the dependency of the ecosystem and its constituent species on flows. Reduction of flows (in full consideration of timing, magnitude, variability) is the most fundamental cause of stress and driver of change to the fishes and food web that have adapted to the tidal and freshwater mixing environment that is the Bay-Delta ecosystem. In addition, some of the other stressors listed and assumed to be addressed through the conservation measures are either directly or indirectly influenced by Delta inflows, exports, and outflows. Until the roles of flows and flow alteration, for which there is substantial literature, are adequately represented in conceptual models and developed in the effects analysis, we are reluctant to rely on its conclusions. We look forward to providing technical assistance on this issue as it is resolved.*

March 2013 Update: The EA has improved discussions of the effects of flow on covered fishes, their habitat and their survival. It also has a set of longfin smelt spring outflow

population simulations and delta smelt fall outflow habitat simulations per our previous recommendations. However, issues resulting from disagreements about the importance of water flows for fish species remain in the draft, including the subjective quality of some of the net effects conclusions, the framing of the effects analysis itself, and some of the biological objectives and stressor reduction targets. As the Service will have to determine which version or versions of water project operations meet statutory criteria for permit issuance, satisfactory resolution of this critical issue for the permit application will require framing the effects analysis appropriately. It will need to clearly articulate that each of the four versions of operations in the current project description has associated with it a distinct effects analysis based on specific assumptions about the importance of water flows through the Delta to covered species that depend on flow. These analyses have substantially different implications for the likelihood that the four operations alternatives will achieve plan biological objectives. These analyses should be presented separately, including analysis-specific net effects presentations, to show how each set of assumptions about the importance of flow leads to different conclusions about the likelihood that each of the four operations alternatives can succeed in achieving the plan's biological objectives. Until the Service can distinguish the effects analysis underlying the "high outflow scenario," which is based on technical advice we provided DWR, this comment will remain a critical issue. The Services discussed this issue with DWR and their consultant, ICF, in early August 2012, and provided them a short white paper on about August 6th, 2012 describing how the the effects analysis should be framed.

The Service also recommends the following changes:

1. Do not confound Delta outflow's influence on delta smelt or longfin smelt recruitment with "transport flows," which is a speculative and unlikely mechanism given the very massive tidal flow connection between Suisun Bay and the western Delta. Delete the analysis of "transport flows" or change it to an analysis of low-salinity zone habitat suitability consistent with Bennett et al. (2002), Hobbs et al. (2006), Hobbs et al. (2010), and Kimmerer et al. (2009).
2. The critical habitat analysis in Appendix 5-I needs to acknowledge the potential negative effect on critical habitat of lower Delta outflow during the summer months per the DOI issue paper dated October 2010.

The Service has provided additional track change edits and bubble comments that we think will improve the document further. If any track-changes comment appears to conflict with the written comments above, the written comments take precedence.

2.4. The Low Salinity Zone (LSZ) is a dynamic habitat defined by the tides and freshwater flow that requires a globally tailored conservation strategy.

April 3, 2013

Original comment: *It is widely recognized that estuarine habitat suitability is driven by the interaction of a flow regime with a brackish, tidally influenced landscape. Changing this interaction by reducing outflow can set a series of ecosystem changes in motion that degrade expected ecological services. In the Bay-Delta, both the flow regime and the landscape are highly altered, and the Preliminary Project proposes new changes. It is well established that variation in Delta outflow or X2 is correlated with many important ecosystem processes and the abundance or survival of estuarine biota. It is also well established that the most important mechanisms and seasons for species that use the LSZ vary. Chapter 5 does not directly grapple with the conservation implications of these and other relevant facts, arguing that the mechanisms causing flow effects on certain fish species are not "well-understood". But the phenomena of species-flow responses are well-developed in the scientific literature. Unless there are concerns about the adequacy of the underlying data, which there may be, flow relationships developed in the scientific literature should be used as the initial basis to predict the effects of changes in flow regime. The effects of flow regime on species and ecosystem processes in the LSZ have been an important subject of study for a long while, and, in addition to their role in the water operations consultations form part of the basis for regulatory processes underway or contemplated by the State Board and EPA. We look forward to working with our partners on resolving the framing of the LSZ habitat analysis.*

March 2013 Update: Status linked to related preceding item: partly addressed, with some issues outstanding. Two follow-up issues under this heading have arisen because the current review includes the whole BDCP and not just water operations and the effects analysis.

(1) The absence of the longfin smelt population growth objective that we have been discussing with our State partners for several months is a critical issue. The Service worked with the California Department of Fish and Wildlife on this objective in the fall of 2012 as a way to require measurable progress toward recovery while allowing the permittee(s) flexibility in how the objective is achieved. In the absence of the objective, it is not clear that the BDCP will need to show progress toward longfin smelt recovery on any timetable. Our understanding is that CDFW has been asked to review the objective now, and its absence from the plan is temporary. We look forward to working with CDFW and DWR on resolution of this issue.

(2) The lack of a "stressor reduction target" for flow for longfin smelt is a critical issue. More than forty years of science has clearly established that Delta outflow is a primary driver of longfin smelt abundance (e.g. Thomson et al. 2010). The Service believes that both tidal marsh habitat improvements and adequate Delta outflow are needed for the plan to achieve a contribution to recovery for this species. The BDCP should include flow as a "stressor" to recognize that conservation of this species involves managing water operations to assure adequate Delta outflow.

2.5. The Low Salinity Zone (LSZ) is the primary habitat for delta smelt and the primary rearing habitat for larval longfin smelt and juvenile to adult splittail.

Our update on this issue is divided into two parts, each associated with part of the original comment.

2.5.a. Original comment: *The Preliminary Proposal modeling indicates that Delta outflows during February- June will more frequently be near the minima required by the SWRCB under D- 1641. This will represent a substantial negative project effect on longfin smelt. The effects analysis and Net Effects only partly address this issue, reporting that Preliminary Project is expected to provide a large, positive impact to food resources that will offset the negative impact to "transport flows". But there are multiple mechanisms by which Delta outflow can affect longfin smelt recruitment; transport flow is only one of them. Transport flows might be managed via gates or other engineering solutions. The other mechanisms for which there is stronger scientific support are kinetic energy mechanisms (low-salinity zone habitat area and retention from gravitational circulation in the estuary). The problems that reduced outflow creates by changing these processes do not have reasonable engineering solutions, and at present appear to be manageable only via outflow. Thus, although some of the potential impact of outflow reductions is reported, the analysis is too narrowly focused.*

Both projected sea level rise and the Preliminary Proposal are also anticipated to cause the average location of X2 to move upstream during the summer and fall. The modeling indicates that intra-annual variability would be lost for several months in the late summer and fall in all water year types; even wet years would functionally become dry years for a third of delta smelt's life cycle. The effects analysis acknowledges this result, but the Net Effects concludes that habitat restoration and food web enhancement will greatly offset this loss of habitat value. The conclusion is in part speculation and in part does not reflect current scientific understanding. This has several implications for delta smelt. First, under the preliminary project delta smelt habitat would less frequently lie in Suisun Bay and Marsh during summer and fall. The habitat suitability modeling shows that this would limit the capacity of tidal marsh restoration in the Suisun region to contribute to delta smelt production. Second, lower summer outflows would increase the length of time that seasonal delta smelt habitat constriction occurs and overlaps with physiologically stressful water temperatures. This means that more food production would be required to maintain current delta smelt growth and survival rates, even in areas where temperatures remain suitable. In areas where temperatures exceed physiologically suitable levels during the summer (~ 24° C), no amount of food production will increase growth or survival rates. Third, the restricted distribution of delta smelt during most summers and essentially all falls would increase the chance that a localized catastrophic event could pose a serious threat to the survival of the delta smelt population.

March 2013 Update: The project description has been updated since the last review to include the "high outflow scenario" that was developed with the Service's advice. This version of operations addresses concerns we have expressed about the adequacy of Delta outflow to support delta smelt and longfin smelt. We continue to have important concerns about the restoration prospects for smelts and representation of the issue in the effects analysis in the eastern and southern regions of the Plan Area. Because delta and longfin smelts are generally pelagic fish, they are not expected to extensively rear in many restored tidal habitats except under very specific circumstances where there is somewhat deep (> 1, but < 4 meters), cool, and very turbid open water (examples: Liberty Island, Suisun Bay,

Sherman Lake). These conditions cannot be created everywhere. Current scientific understanding suggests that some regions of the Plan Area are unlikely to be good places for delta and longfin smelt – especially if the only practical option is to flood subsided Delta islands; existing examples include the interiors of Franks Tract and Mildred Island.

Looking at the proposal as a whole, estimates of tidal marsh restoration acreages may be overstated simply because the physical characteristics of the Estuary cannot support the objective. As discussed in comment 2.1, upstream areas in the Estuary (east of the major constriction at Carquinez Strait and other locations) may not receive sufficient tidal energy to be tidal habitat; this outcome would greatly reduce the expectation of benefit to the smelts if our belief that benefits arise primarily where tidal fluxes mix fish prey items into open-water river channel areas is well-founded (see Lehman et al. 2010). We are concerned that actual acreages that are restored – indeed, that *can* be restored, if there is to be an expectation of marginal benefits to native aquatic species accruing at each step – will be only a small fraction of what the BDCP proposes. This is not necessarily a fatal problem: given the uncertainties of restoration, it may prove most beneficial to attempt restoration on a smaller (but still large) scale. The remedy for this issue in the present draft is to more accurately characterize these effects and the challenges they pose, to lay a foundation for the intensive study and adaptive management that will be required during implementation.

The Service also suggests the following additional specific changes should be incorporated to better address Recommendations 2, 3, 4, 6, 13, and 15 of the June 2012 DSP Review Panel report :

1. Sensitivity analysis of the Habitat Suitability Indices including the variance that arises using alternative input assumptions as described in our detailed comments above.
2. Use of a more sophisticated splittail Habitat Suitability Index; the current one only uses depth as a determinant of splittail habitat suitability. We do not find that to be a compelling argument. Splittail migrate to different habitats to complete different parts of their life cycle, so there must be additional factors that define habitat suitability for fish of different ages. There is information on splittail temperature limits, salinity distributions, seasonal timing of occupancy of particular regions, etc. in the literature.
3. The Net Effects summary graphs should include “uncertainty bars” that are larger when uncertainty is higher and smaller when uncertainty is lower so that both expected magnitude and confidence in the conclusion are simultaneously conveyed. The 2012 independent science panel report has some useful advice on this.

As a supplemental response on this item, the Service has provided additional track change edits and bubble comments that we think will improve the document further.

2.5.b. Original comment: *Turbidity is another important component of delta smelt habitat suitability. Section C.4.1.4 ("Turbidity") states: "[f]irm conclusions regarding changes in turbidity in the BDCP Plan Area are difficult to make." But some large-scale changes in sediment fluxes might affect turbidity on scales important to smelt, and should be straightforward to analyze. The Sacramento River is the most important contributor of sediment to the Bay-Delta. According to the Effects Analysis it contributes an estimated 80% of its load during high flow events. The North Delta diversions in the Preliminary Project have the ability to take up to 15,000 cfs during high flow events. For a 70,000 cfs event, this could be 20% of the Sacramento River water including its suspended sediment load. The effects analysis makes no attempt to analyze how much sediment loss per year that would represent and whether it would change the ratio of supply to loss of sediment from the estuary. The same calculations should be done for the south Delta to give the results full context. In summary, the current Effects Analysis does not appropriately deal with critical issues involving the role of the Low Salinity Zone as habitat for longfin smelt, delta smelt, and splittail. Until it addresses the right questions regarding flow, LSZ location, and turbidity, we are reluctant to rely on its conclusions. We look forward to working with our partners as these issues are resolved.*

March 2013 Update: The proposed conveyance capacity has been reduced to 9,000 cfs and the revised EA has a greatly improved scientific discussion of turbidity, including the requested estimate of sediment that would be removed by diverting water directly from the Sacramento River. These changes are helpful responses to our prior concern, which was echoed in Recommendation 12 of the independent science panel's June 2012 report.

This remains an important issue, because we are concerned that an average loss of 8-9% of sediment will have greater negative effects on delta smelt and longfin smelt and their habitats downstream of the diversions than are acknowledged in the effects analysis and net effects, and will likely encourage the growth of exotic aquatic plants in the lower Sacramento River and in off-channel tidal marsh areas. This issue is also discussed in comment 2.1 above.

As a supplemental response, the Service has provided additional track change edits and bubble comments that we think will improve the document further, particularly in Chapter 5.5 where we think that based on the collective discussion and analysis in the EA, the likelihood of generally lower turbidity in the Sacramento River and North Delta in the future is stronger than the draft document suggests.

2.6. There is no reason to expect that invasive vegetation will not proliferate in the East and South Delta ROAs, and no reason to expect a meaningful increase in south Delta turbidity if vegetation could be successfully controlled.

Original comment: *There should not be an a priori assumption that SAV can be controlled via ecologically sound methods in the east, central and south Delta. These are comparatively low turbidity, high vegetation areas already, under the existing hydrodynamic regime. There is nothing in the Preliminary Proposal that would dramatically change channel geometry,*

April 3, 2013

increase SJR flows, or increase sediment inputs that could be expected to change the turbidity of the entire southern half of the Delta.

March 2013 Update: Chapters 3 and 5 have greatly improved scientific discussions of invasive vegetation. These changes are helpful responses to our prior concern about the effects analysis, which was echoed in the independent science panel's recommendations 6, 8, and 16 from the June 2012 report.

We suggest avoiding claims that particular projects or ROAs will contribute (by themselves) to population level goals and objectives for delta and longfin smelt. There are likely thresholds in the extent of tidal marsh habitat that needs to adjoin areas of open-water in order for the marsh to subsidize the open-water instead of generating circumstances where the productivity is consumed within the marsh or quickly consumed by bivalves (clams) as it is dispersed from the marshes and other shallow areas. Such thresholds would depend on a number of factors and might be hard to predict. This possibility, and the potential path-dependence of the outcome of restoration, represent two key uncertainties that we hope the BDCP Adaptive Management Program can address.

As a supplemental response, we have provided track change edits and bubble comments that we think will improve the document further, particularly in Chapter 3 and 5.5.

2.7. Chapter 5 is deficient in its descriptions of channel margin, riparian, and floodplain habitat restoration outside of Yolo Bypass.

Original comment: *The Yolo Bypass tends to benefit native fishes because (1) it floods frequently with major inundation events; (2) it floods during times of year that BDCP target fishes can, and have evolved to, use it; and (3) upon drying it leaves very little permanent habitat for non-native fishes to colonize and reproduce in, because most non-native fishes are late spring/summer spawners. The original habitat analysis attributed seasonal floodplain benefits along the San Joaquin River that we do not believe are plausible; however, we understand there is now general agreement on this point and we will not comment on it further. However, the Sacramento River from Sacramento to about Rio Vista is also highly constrained, in this case by levees rather than regulated hydrology, and there are strict flood control capacity requirements that are enforced by USACOE. The effects analysis does not describe how this constrained reach of the river can support the proposed changes, where they will be, or assess their feasibility.*

March 2013 Update: NMFS independently articulated these concerns last year, and we defer to their analysis of the response in the new draft BDCP (see NMFS memo comment 1.14).

2.8. Increased residence times and reduced flushing of the Delta by Sacramento River water appear likely to result in interior-Delta channels that are further dominated by agricultural runoff, invasive aquatic vegetation, warmer

April 3, 2013

temperatures, and increased algal productivity with its associated dissolved oxygen swings.

Original comment: *These environmental conditions favor non-native/invasive species (e.g. Egeria densa, largemouth bass, water hyacinth, Microcystis) and disfavor native fishes. The Delta is already more biologically similar to a lake than it once was, due to the historical accumulation of human modifications. We expect that by reducing Delta flows, the Preliminary Project would likely facilitate the spread of habitat conditions that are unfavorable to delta smelt, and and less favorable to other target fish species survival and recovery.*

March 2013 Update: Chapters 3 and 5.5 have improved scientific discussions of residence time in the southern Delta and its likely connection to invasive vegetation and *Microcystis* blooms. These changes are helpful responses to our concern about the effects analysis, which was echoed in the DSP Science Panel Recommendations 6, 7, 8, and 13 in their June 2012 report.

Issue Area 3: The Effects Analysis relies on selective use and interpretation of statistical and mathematical models

3.1. The effects analysis did not use the available splittail life cycle model at all to support its Net Effects conclusion.

Original comment: *There is a published stage-based life cycle model for splittail where the effects of various environmental variables were examined for their effects on long-term trajectory of population abundance. This model helped frame the preferred time-interval for floodplain activation necessary to ensure splittail persistence in the Central Valley. This available approach to an Effects Analysis for a listed species of native fish was not discussed in the present Effects Analysis.*

March 2013 Update: During our conversations with DWR and the consultant last fall, Service staff agreed that it was not necessary to use the splittail life cycle model in a predictive mode because that exercise had been completed to the extent it could be in the paper in which it was published. We appreciate the model description added to Appendix 5G.

3.2. The effects analysis did not use the best available longfin smelt statistical models to support its net effects conclusion.

Original comment: *The newest published statistical analyses of longfin smelt are quasi-life cycle models that account for prior abundance and spring flow influences (among other factors) on this species. These models were discussed and discounted as not being 'life cycle models'. Dismissing them because they are not 'life cycle models' is unhelpful: they are the best available scientific tools to evaluate project effects on longfin smelt. The older regression models that were used in the effects analysis are published, but can easily be shown not to perform as well as the newer models. The older models also average the flow influence on longfin smelt across half a calendar year, which likely affects conclusions about the reduction*

April 3, 2013

in springtime outflow seen in modeling outputs for the Preliminary Proposal. We look forward to working with our partners and providing technical assistance as this issue is resolved.

March 2013 Update: There has been a great deal of new data analysis on the topic of longfin smelt response to Delta outflow that has occurred since last spring in response to the "CS5" exercise, though we acknowledge this work remains to be published. The Service provided ICF with these new analytical tools last fall and one of them has been incorporated into the EA as an additional or alternative means of evaluating the expected long-term impact of BDCP influence on the spring Delta outflow "mechanism(s)" that is part of the well-established relationship between longfin smelt recruitment and Delta outflow.

We also provided ICF with a linear regression tool, but we did not see results based on it in the revised EA. This is an important issue because both its linear and nonlinear regressions should be used in the EA, as they are based on different plausible assumptions about how to represent current and potential longfin smelt population dynamic responses to flow variation and food web restoration. These are important approaches to present as part of the foundation for the adaptive management studies of outflow that are under development.

These adjustments will help address Recommendations 10 and 17 in the 2012 independent panel's review.

3.3. The effects analysis continues to insist on an analytical approach to entrainment that does not reflect the best available science.

Original comment: *The current Draft Effects Analysis (as of September 13, 2011) downplays the potential effects of entrainment to the delta smelt population: (e.g., Section B.1.1.1), "[H]owever, analyses to date have not found correlation between entrainment and population level responses of delta smelt ..." The delta smelt population is now at historically low abundance and population losses due to entrainment may have significant population effects depending on their magnitude and frequency. While it is true that some regression-based analyses have failed to reveal an export affect to the delta smelt population, other approaches that more effectively investigate the role of fish distribution to entrainment have revealed an important relationship between water operations and the risk of population-level entrainment effects to delta smelt. Kimmerer (2011) demonstrated that entrainment losses averaging 10% per year can be "...simultaneously nearly undetectable in regression analysis, and devastating to the population." We look forward to working with our partners to ensure that the best model-based analyses of proportional entrainment for both South- and North-Delta diversion facilities are brought to bear to resolve this issue.*

March 2013 Update: The original issue has been sufficiently addressed. We have provided additional track change edits and bubble comments that we think will improve the document further in Chapter 5.5. However, an important related issue remains. The stressor reductions targets for entrainment of the two smelt species propose to have

proportional entrainment “at a level below the average” observed from 1995-2012. Achievement of these targets is already assured by the existing USFWS BiOp, and should be improved upon in a dual conveyance scenario. Furthermore, there is no rationale to explain why positive effects of achieving low rates of entrainment will not affect the fish populations until “year 40” [delta smelt] or “over time” [longfin smelt]. Since reducing cumulative entrainment of these species to no more than 5% of the population is already a BDCP biological objective, a more sensible stressor reduction target would be framed in terms of variables that affect entrainment risk.

3.4. We think that the delta smelt state-space model is a useful framework to explore hypotheses about what drives delta smelt abundance.

Original comment: However, the Maunders-Deriso model is a new application that needs additional collaborative work before it reaches maturity. We are concerned that the present model may have identifiability problems, as we discussed in our technical comments last fall. Until that concern is resolved, we are unsure whether the parameter estimates developed in that model represent what they are described to represent. We are also unsure why the model uses the official DFG Fall Midwater Trawl Abundance indices for delta smelt, but does not use the official DFG Summer Trawl Survey or 20 mm Survey abundance indices. The rationale for this (which may be simple) is not explained. The model also assumes a specific form of density dependence between generations. We have questioned the appropriateness of this choice, because on very thin ground it limits the universe of plausible explanations for delta smelt reproductive success that can be derived from the model.

The intent of this new model was to explain a specific historical dataset, and other than some broad assumptions it does not contain much of the mechanism presented in current delta smelt conceptual models (like DRERIP, or POD conceptual model, or the Fall Outflow Adaptive Management Plan conceptual model). The published version of the model used data through 2006. The model was updated for the Effects Analysis to include data through 2010. When this was done, the model fit deteriorated dramatically relative to what was reported in the paper. While this does not (at all) cause us to think it should be discarded, it does underscore questions about the maturity of the tool. The current model's success in fitting a specific set of historical data may not translate to good predictions of the effects of flow and habitat change. The current model may perform still more poorly when CALSIM II water operations outside the envelope of historical experience are used as input.

It is important for the Effects Analysis to acknowledge that some data that may prove to be essential to modeling delta smelt or longfin smelt dynamics have been collected only recently. There are a number of studies now underway that address questions about fall outflow processes and delta smelt ecology as a whole. The novelty of the Maunders-Deriso model, and existence of other tools and analyses taking a process-oriented approach to predicting the effects of flow and habitat changes, make the framing of the effects analysis very important. It is equally – possibly more – important that uncertainty at all levels be properly developed and acknowledged. Achieving these things, which are important to having an effects analysis we can rely on, will require work and a willingness to adapt on the part of ICF. We look forward to continuing to work with ICF and our other partners to ensure that the best science is identified and used defensibly in the effects analysis.

April 3, 2013

March 2013 Update: The track changes edit of the Fish Life Cycle Models Appendix 5G pdf provided by ICF seems to have edited out the descriptions of the Maunder and Deriso (2011) and Miller et al. (2012) statistical life cycle models. Here, we clarify that we did not ask for such a change to be made, and do not think it is either necessary or appropriate to strike descriptions of these analyses from the supporting materials for Chapter 5. It was mutually agreed that the Maunder and Deriso model was not a suitable *forecasting* tool in its current state, but the EA should retain a description of what it is and the findings of their exploration of the input data. The same is true for the statistical models of Miller et al. 2012, Thomson et al. 2010, and Mac Nally et al. 2010, because it is the findings that these different analytical approaches have in common, including the difficult bioenergetic situation that delta smelt face from late spring through early fall, that may emerge as robust and valuable conclusions of the modeling exercises carried out to date.

Issue Area 4: The BDCP's net effects conclusions rest on an equivocal food web conceptual model

4.1. The FWS agrees that the pelagic food web that historically supported greater abundance of estuarine fishes including longfin smelt and delta smelt has been impaired and that contributing to its restoration is a key component of a conservation strategy for the Bay-Delta.

Original comment: *However, food limitation is a ubiquitous feature of ecology in the Bay-Delta. It affects non-native species as well as the BDCP target species. Thus, the issue is not really "food limitation" per se. Rather, the issue is food web pathways and the number of steps in a food chain between primary producers (phytoplankton and plants) and the BDCP covered fishes. For the smelts, the desired food pathway would be dominated by this short food chain: diatoms → calanoid copepods and mysids → low-salinity zone fishes. The short food chain outlined above dominated the historical low-salinity zone food web. Longfin and delta smelt are highly dependent on it (and minor variations of it). The other BDCP target fishes also use it, but have more generalized diets that often include benthic organisms and riparian and floodplain insects. The draft appendix has a very long section on food web changes when a simpler summary of the major points would be more effective.*

*The focus of food web restoration in the effects analysis is on floodplain and tidal marsh restoration. The production of diatoms may have been limited by disconnecting floodplains from their rivers and by reclaiming tidal marshes. These are the primary hypotheses behind the BDCP habitat restoration conservation measures. However, the two best-substantiated drivers of diatom suppression are overbite clam grazing and ammonium concentrations in the estuary. The suppression of diatoms is hypothesized to have provided a competitive advantage to lower quality primary producers and primary producers like *Egeria densa* and *Microcystis* that have virtually no food web value to the BDCP target fishes. This change in the base of the food web has reduced the amount of fish production that can be supported by the historical diatom-based food chain, and forced the fish to rely on other longer and more energy-limited food pathways. Longer food chains are less productive, and do not support as many fish. Because splittail and young Chinook salmon are the covered species that most*

April 3, 2013

extensively utilize floodplains and tidal marsh networks, they should be expected to gain the greatest food web benefits that restoration of these habitats can provide. However, this is not what the Net Effects concluded. Rather, it concluded that habitat restoration would provide greater benefit for the smelts despite their limited overlap and more restricted diets.

Shortcomings in the Net Effects resulting from mischaracterization of processes limiting transfer of production in new habitat areas to native fish biomass renders the present analysis inconsistent with best available science, and we are reluctant to rely on it to judge the design of the preliminary project. As with other modeling issues, we look forward to working collaboratively with our partners as these issues are resolved.

March 2013 Update: The revised Chapter 5.5 has improved regarding its acknowledgement about the drivers of the estuarine food web (clams and nutrients). The changes would have represented a larger improvement if they had included a more detailed analysis of unintentional restoration experiments (see update to comment 2.1 above). Such an analysis would have helped address Recommendation 8 of the 2012 independent review panel report, and helped avoid logic problems like those discussed below.

The Conservation Measure 4-based approach to solving food web issues for smelts is only weakly supported in the scientific literature. The document itself states (Appendix 5E):

To be used in the analysis, sufficient data had to be available to describe the condition at the scale of the geographic subregion, and it was necessary to be able to forecast conditions in the future with and without the BDCP either through modeling or conclusions. For example, planktonic food is an important factor in defining habitat for delta smelt (Bennett 2005) that likely relates to the presence of certain species of zooplankton (Criterion 1). **However, there is not sufficient data to characterize zooplankton abundance or community structure at the scale of the subregion (Criterion 2), nor is there an ability to project zooplankton response to future conditions [emphasis added].**

The proposed use of turbidity as a substitute for food is also not supported by best available science:

To incorporate a measure relating to feeding, turbidity was used as an indicator of feeding potential in the subregions and in restored habitat (the potential of the restoration to add to the food supply in the Delta was treated as a separate analysis in Section 5E.4.3). Delta smelt abundance is strongly correlated with high turbidity, and it is believed to relate to the ability of fish to find and capture prey (Bennett 2005) (Criterion 1). There is sufficient information collected as part of the regional fish monitoring programs to characterize turbidity in the subregions (Criterion 2). At the present time there is no model available to project turbidity in the future, although there is reason to expect that turbidity in the Delta may decline in the future (Ruhl and Schoellhamer 2004). Recognizing the strong association with delta smelt presence,

April 3, 2013

turbidity was used as a factor in the delta smelt model, but turbidity was assumed not to change over the BDCP period (Criterion 3).

We remain skeptical of the use of turbidity as a substitute for smelt food supply, and more skeptical of the conclusion that this supply will remain unchanging into the future given the acknowledgment that turbidity values in the Estuary are expected to decline through time. The EA itself suggests sediment supply will be reduced by 8-9% by the North Delta diversions. For additional advice, see Recommendation 8 from the June 2012 DSP review panel (Accurately characterize food resources and food webs).

The Habitat Suitability Analysis does not include an accurate estimate of food/prey availability and fate for either of the smelts for existing or proposed future conditions. The phytoplankton productivity estimate taken from Lopez et al. (2006) is an instantaneous productivity rate the authors themselves describe as not reflective of general habitat and hydrodynamic conditions in the Delta. A more accurate analysis of the productivity of Delta tidal environments would include analysis of the transport and fate of productivity in the Delta environment. Specifically, Lopez et al. (2006) underscore the evidence that much of the productivity in the Delta is being shifted to the benthos by exotic bivalves and away from the pelagic environment. The authors emphasize that analysis of instantaneous productivity estimates might, therefore, not yield meaningful answers if the role of the bivalves is neglected. The article includes the passage: "The unexplained patchy distribution of *Corbicula fluminea* in the Sacramento-San Joaquin Delta implies high uncertainty in the outcomes of creating new aquatic habitats (Lucas and others 2002)." The Effects Analysis assumes an increase of 40% in productivity available to the pelagic food web as the result of the proposed restoration program. Given the findings of Lopez et al. and others (e.g. Nixon 1988, Cloern 2007, Lucas and Thompson 2012), we believe the actual improvement in system-wide productivity increase to the pelagic food web is very uncertain and might be substantially less than 40%. As with some other comments (e.g., update to comment 2.5.a above), the remedy to this issue is to more objectively assess the effects.

As a supplemental response, the Service has provided numerous track change edits and bubble comments that we think will improve the document further.

Issue Area 5: The analysis and interpretation of BDCP are hindered by indeterminate model baselines and related issues

5.1. A key point of continuing analytical confusion is the use of multiple baselines.

Original comment: The current set-up for the BDCP employs two 'base case' model runs (EBC1 and EBC2). The EBC1 does not include the full suite of elements in the current FWS and

April 3, 2013

NMFS OCAP RPAs. The EBC2 attempts to include the RPAs in their present-day form, but it does not accurately capture them all. There are numerous cases in Chapter 5 where it is not clear what Project model result is being compared to which baseline condition. This generates confusion. We look forward to continuing to work with our partners to be sure that baselines used in the effects analysis are appropriately constructed and are used clearly and correctly.

March 2013 Update: As a result of this comment, ICF is developing a scope to conduct a new “aggregate” analysis that meets the needs of FWS and NMFS. FWS intends to continue to work with them and the other agencies to complete this analysis and incorporate it into the effects analysis of the proposed project prior to submitting the section 10 application.

5.2. CALSIM II demand representation in 2060 studies should have some justification.

Original comment: *Some explanation for, or error estimate of, assuming a 2020 level water demand for a 2060 climate change simulation should be made. Presumably portions of the State (Southern California, the American River Basin, etc.) are going to continue to grow through 2060. Some estimate in the change of cropping patterns over the 40 years (2020 – 2060) should also be made (or at least a write-up of why it cannot be made) should be included. Without clear resolution of this issue, it appears to us that the modeling may underestimate water demand in the late long-term. We are unable to provide technical assistance on this issue, but look forward to its resolution.*

March 2013 Update: ICF responded to this comment by noting that water demand in the export area was expected to top out at a 2020 level. However, this important issue remains unresolved because we could not find where in the documentation that it is stated explicitly that it is an analytical assumption of the BDCP EA that demand growth upstream of Freeport will top out at a 2020 level. Fix: please clarify that it is a modeling assumption that a 2060 climate will interact with a 2020 level of water demand in the Late Long-Term.

5.3. The proposed restoration in each “Restoration Opportunity Area” (ROA) is only compared against the lands bounded within the ROAs, which themselves lie in larger regions.

Original comment: *These comparisons of present-day ROA habitat to future ROA habitat are inappropriate – especially in cases like the east and south Delta ROAs, which are currently dry land. Mathematically, if a terrestrial habitat is subsequently flooded, the improvement for target fishes increases by an infinite percentage even if the habitat performs poorly because a habitat suitability index that is even a tiny fraction of 1 is still infinitely higher than zero, which is the suitability of dry land to fishes. Habitat analyses need to be based on comparisons against currently available aquatic habitat acreages in the entire regions containing the ROAs. They also need to be synthesized and integrated into Plan Area-wide totals, with river flow and climate changes incorporated, in order for the analyses to be meaningful.*

April 3, 2013

March 2013 Update: This specific representation issue appears to have been sufficiently addressed in the EA. Full resolution of issues related to evaluation of habitat restoration in the EA is contingent on implementation of fixes that are discussed above.

Resolution of the issue will help address Recommendations 5 and 6 of the June 2012 independent review panel report.

PART II: NEW ISSUE AREAS ARISING FROM REVIEW OF DECEMBER 21, 2012 AND MARCH 6, 2013 BDCP DRAFTS

Issue Area 6: Plan adaptability

6.1 Clarify the role of biological objectives as the basis for adaptive management of BDCP conservation measures. Biological goals represent the ultimate conservation outcomes toward which the Plan strives. In some cases, achievement of ultimate goals lies within the power of the BDCP; in others the achievement of goals depends in part on factors that are outside the control of the water projects. Objectives are lower-level outcomes within each goal that are achievable by the BDCP and essential to achieving the overarching goal.

BDCP conservation measures are designed to achieve the biological objectives of the Plan. Because of this, BDCP adaptive management must be structured to provide for adjustment of the conservation measures to achieve the objectives as efficiently as possible.

The document is generally clear that the BGOs will be used to guide the implementation of conservation measures. However, the plan needs to clearly articulate that achieving biological objectives is the whole basis of the conservation plan. Achieving and continuing to achieve objectives will be necessary for progress toward the biological goals and recovery of covered species, and may be required for compliance with the HCP permit. There are several passages in Section 3.6 and elsewhere that need to be edited to clarify the role of the biological objectives.

6.2. The BDCP must set forth governance and adaptive management plans that will facilitate adaptive management. A core feature of the management problem the BDCP is designed to address is uncertainty. Three years ago, the Federal Agencies issued a white paper on application of the Services' 5-point policy for HCPs to the BDCP. It articulated the role of two permitting strategies developed in the 5-point policy: prescriptive plans and outcome-based plans.

"The BDCP is a complex, landscape scale, long-term HCP with a high degree of uncertainty as to how close the initial conservation measures will come to achieving the plan's biological goals and objectives. It falls into the category of plans that will be a mixture of the two strategies, with initial prescriptions associated with

April 3, 2013

adaptive management, and specific biological outcomes defining the ultimate success of the plan. This type of plan will allow management flexibility so the permittee may institute actions necessary to achieve the plan's goals while providing boundaries for future expectations and commitments. In addition, a results-based plan will address uncertainty in the ecosystem and provide the conservation assurances required by the Act. The Services will be challenged to make the findings required for permit issuance if the plan does not include clearly defined and scientifically supported biological goals and objectives, an adaptive management plan that tests alternative strategies for meeting those biological goals and objectives, and a framework for adjusting future conservation actions, if necessary, based on what is learned." (4/29/2010 memo, page 1)

In an outcome-based plan, biological objectives provide targets that conservation measures are expected to reach, thereby contributing to the conservation outcomes required by the permit. If the objectives have been appropriately crafted, their achievement assures that a project is doing what it can to contribute to the accomplishment of the ultimate biological goals of the plan. If the CMs fail to achieve the biological objectives around which they are designed, then the plan must provide the means (adaptive management) to change the conservation measures to achieve the outcomes.

We are concerned about the ability of the draft BDCP to successfully facilitate adaptive management. Our concerns span chapters 3, 6, and 7. A large number of issues our staff have identified in Section 3.6 remain unresolved. Also, discussion between the Service and DWR regarding the content of Chapter 6 is not yet complete. Because these sections are "works in progress," the following list of critical issues is not exhaustive.

(1) Absence of a decision table in Chapter 7 (Governance). The most basic function of Governance is to define who makes decisions. In July 2012, the BDCP principals adopted a draft table describing how key BDCP implementation decisions are to be made, what the elevation path is if there is disagreement, and who has final authority to decide. Unfortunately, the decision table was removed from Chapter 7 shortly thereafter. In its absence, the Governance chapter does not clearly define or summarize how important classes of decisions would be made, including adaptive management changes, and leaves equally unclear who would have final authority to decide in each class of decision. Restoring the July 2012 governance decision table, or writing a new Section conveying the information in that table, is necessary to provide a clear path for decision making in the document and for plan implementation.

(2) Ambiguity in roles and responsibilities in Chapter 7. There remain ambiguities or apparent conflicts in roles and responsibilities in the Chapter 7, including Section 7.3.4. Clarifying the roles of the adaptive management team, the science manager, and the program manager is a critical issue, given the potential difficulty of the decisions that lie ahead. Adaptive management is fundamental to the BDCP, and the plan should be

April 3, 2013

unambiguous that scientific studies, development of proposals to adjust the conservation measures based on new information, and other adaptive management functions will be managed and administered jointly by the parties that form the Adaptive Management Team, and not by the Implementation Office or its employees and officers, except to the extent that one of them (the Science Manager) is a member of the Adaptive Management Team.

(3) Ambiguous limits on adaptive management changes to conservation measures in Chapter 3. As an example, Section 3.6.3.3.2 limits circumstances in which adaptive changes to conservation measures can be implemented:

With respect to adaptive changes to conservation measures that would result in a greater commitment of water, land, or money by the permittees, the scope and magnitude of an adaptive response will be limited to those actions reasonably likely to ensure that (1) the impacts (or levels of impacts) of a covered activity that were not previously considered or known are adequately addressed or (2) a conservation measure or suite of conservation measures that is less than effective, particularly with respect to effectiveness at advancing the biological goals and objectives, is modified, replaced, or supplemented to produce the biological benefit. (pages 3.6-26 to 3.6-27 in March 2013 BDCP draft)

A permanent adaptive change to a BDCP conservation measure will most likely be needed because (a) the conservation measure is not achieving or not on track to achieve the biological objective(s) it is designed to achieve; or (b) a different version of the conservation measure that costs less water or money to implement has been found that is equally effective or more effective at achieving the relevant biological objectives. This formulation should not be controversial: it is the basis of adaptive management in many other systems, and articulates the way the conservation measures would be managed to achieve the co-equal goals of the BDCP.

We are concerned by the ambiguity of the limits described in the quoted passage above. In our view, they can be interpreted to allow the changes (a) or (b) we have listed, but they can also be interpreted to prohibit them if they cost water, depending on whether “advancing the biological goals and objectives” and “produce the biological benefit” both mean ‘achieving the objective(s).’ It is also not clear what other kinds of adaptive management changes the limits might prohibit, or are intended to prohibit, since the text was presumably inserted for a specific reason. This sort of ambiguity, which has other examples, is very problematic in a plan that depends on adaptive management and is meant to provide a clear, cooperative mechanism to implement it. Left as is, these ambiguities seem likely to add new conflict on top of already-difficult management problems.

April 3, 2013

(4) Lack of clarity on how AMT implements adaptive management. The Service has identified a large number of issues of varying levels of importance in Section 3.6. They include confusing language about circumstances “triggering and adaptive response” that do not align with the 9-step adaptive management model adopted by the BDCP; ambiguities in how decisions are made, including at least one example in 3.6.3.3.2 (page 3.6-27) that appears to conflict with the July 2012 Governance decision table discussed in 6.2(1) above; and other issues. It will be very important to follow-up on these issues to ensure that the adaptive management process is clearly defined and workable.

The plan also needs to clearly articulate that the science program developed to support adaptive management will be structured to facilitate participation by agency scientists, stakeholders, and a broad array of academic scientists. The current provisions for participation by stakeholder participation and science do not adequately lay out the stakeholder roles in the technical dialogue and do not clearly develop an appropriately expansive role for academic scientists. The current draft is also vague on the role of the Delta Science Program, which we believe may play a crucial role in assuring the quality and transparency of science in the BDCP.

The Delta Science Plan, which is under preparation, is likely to propose a broad collaborative science structure that includes direct science/policy discussions involving agency executives and senior academic scientists. We view this as a very good idea. We also recommend that the draft Science Plan be included in the discussion going forward, since the Delta Science Plan will become part of the management environment in which a BDCP would be implemented. Separately, a recent draft memorandum prepared by the Delta Stewardship Council’s Independent Science Board expressed skepticism that the current draft BDCP governance chapter does enough to facilitate cooperation in the adaptive management program. Given the stature of that panel, its critique should also be part of the dialogue going forward.

6.3 The Decision Tree. The decision tree articulates the concept that four sets of operational criteria will be proposed in the project description. They include the “high outflow scenario,” which was developed with the advice of the Service, and three alternatives that provide reduced Delta water flows. Given the fundamental disagreements that exist over the importance of flows for covered fish species, it is reasonable to investigate these other scenarios as initial management alternatives through the adaptive management program. However, the March 2013 language of Section 3.4 is ambiguous on the role of these alternatives in the BDCP permit.

CM1 includes two decision trees, one for fall outflow and one for spring outflow, that specify alternative outcomes for each criterion. Because each decision tree has two possible outcomes, the decision trees lay out four possible outcomes in outflow criteria when the spring and fall outflow components are combined, as described in Table 3.4.1-1. These four outcomes would be covered by the permit. These operating

April 3, 2013

criteria will be subject to a determination by the permitting agencies, based on best available science developed through the decision-tree process, specifying what the spring and fall outflow criteria will be at the time CM1 operations begin. (March 2013 BDCP, page 3.4-19)

We have two concerns about this passage, as written. First, the meaning of “covered by the permit” in the third sentence is ambiguous, but it could be interpreted as an expectation that the permit would include findings that the whole project description, including all four versions of water operations, satisfies statutory issuance criteria. It is not clear how the Service could make such findings at present, since the project description as a whole does not fully implement the Service’s 2008 Reasonable and Prudent Alternative for CVP/SWP water operations. We interpret the sentence to mean, instead, that all four versions of operations would be analyzed prior to potential permit issuance, findings would be made with respect to each alternative version of operations based on the best available science, and the result of those analyses would be expressed in the permit.

Second, the last sentence seems to imply (“[t]hese operating criteria will be subject to a determination...”) that if the initial finding is revisited prior to the start of CM1 operations, the new finding would be limited to a choice among the four original operations alternatives. It may be that this is not the intended meaning. Bullet #3 near the bottom of the page says “[a]t the time dual conveyance operations begin, the permitting agencies identify spring and fall outflow criteria sufficient to meet the biological goals and objectives,” which seems clearly to articulate that the decision at the time of CM1 operations would not be constrained to a choice among the original four alternatives. If, however, the intended meaning of these passages is that the choice of operations a decade or more in the future is to be limited to a selection among the four original alternatives, regardless of the results of new scientific studies everyone agrees are important, that would be highly problematic.

We are very concerned by the ambiguity of these statements, and other statements in Section 3.4 and its tables regarding the decision tree, which seem very likely to cause conflict in the future.

6.4 Changed Circumstances. There are numerous problems with the latter sections of Chapter 6 (6.4 and 6.5). The list of foreseeable changed circumstances described in 6.4 needs to be expanded and the range of adaptive responses available to address those changed circumstances is far too narrow and limiting. The subject of range of adaptive responses is directly related to the subject of adaptive limits, which also have not been defined. Changed circumstances should also include a time-frame for implementation of the remedial measures. The 5-Agencies will need to review this section and come to agreement on revising its contents prior to release of the public draft of the plan. More detailed comments on the issues with this section of Chapter 6, which are intended to start a dialogue on the chapter, are provided in our “track-changes” submittal.

April 3, 2013

6.5 Adaptive Limits. “Adaptive limits” in the BDCP refers to the most extreme sets of practicable operational parameters that might be required of or authorized to the permittee through the working of adaptive management over the life of the permit. Some discussion of what such parameter-by-parameter limits might be has already occurred, but neither the concept of adaptive limits nor a draft example of them is included in the current BDCP draft. Without adaptive limits, limits to the commitment of resources that might be required of the permittee(s) remain undefined.

As is clear in both the HCP Handbook and the Five Point Policy, the permittee(s) in an HCP is protected by the inclusion of adaptive limits that “clearly state the range of possible operating conservation program adjustments due to significant new information, risk or uncertainty. This range defines the limits of what recourse commitments may be required of the permittee(s). This process will enable the applicant to assess the potential economic impacts of adjustments before agreeing to the HCP.” 65 Fed. Reg. 35253; see also HCP Planning Handbook at 3-24 – 3-25.

In the BDCP, adaptive limits would provide an important assurance that would protect the permittee(s) from an open-ended obligation to commit resources irrespective of circumstances. They would also provide an important level of transparency to the permittee(s) and the public regarding the commitments represented in the plan. It will be important to clarify the effect of changed circumstances (Section 6.4) on the adaptive limits.

We are also concerned that the four operational alternatives in the project description might be interpreted to represent the adaptive limits for the permit. This is not an appropriate interpretation, and it will be important to cross-check the relevant chapters to be sure it is clear that operations might be adjusted in ways that cause water yield to move up or down within the adaptive limits, depending on new scientific findings.

6.6 Real-time operations. Real-time operations, described in CM1, are discussed in chapter 3 under 3.4.1.4.5 and are described as being separate and distinct from the adaptive management process. Yet the document is confusing because Chapter 3 states that the purpose of the adaptive management process is to allow for adjustments to be made to conservation measures, including operational criteria. It will be important going forward to clarify the governance and management of real-time operations.

END

STATEMENT AVAILABLE FOR RELEASE – THURSDAY, JULY 18, 2013

Federal Agency Comments Received on the Bay Delta Conservation Plan (BDCP) Second Administrative Draft Environmental Impact Report/Environmental Impact Statement (EIR/EIS)

The federal lead agencies for the BDCP EIR/EIS, the U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, and National Marine Fisheries Service, provided their state partner, the California Department of Water Resources (DWR) and the environmental consultants with comment memos on the Consultant Second Administrative Draft EIR/EIS (Admin Draft), released on May 10, 2013. These comments are offered to improve content and readability of the Admin Draft. State and federal lead agencies for the BDCP EIR/EIS are confident that the issues identified in the comment memos will be resolved in the ongoing development of the BDCP and environmental review process, including the public review draft EIR/EIS scheduled for release this October and the final EIR/EIS.

"These comments are intended to be helpful and underscore the good collaboration that exists in this complex planning process," said Will Stelle, NMFS West Coast Salmon Coordinator. "We anticipate that, like the issues that are currently being discussed in relation to the draft habitat conservation plan, these issues can be dealt with in a manner that is acceptable to both the state and federal agencies involved."

"Securing California's foundational water supply for two-thirds of the state against the certainty of sea level rise and earthquakes remains a top priority of the Brown administration," said Natural Resources Agency Deputy Secretary Jerry Meral. "In context, it is important to remember that regulatory agencies by their nature do not give out 'gold stars' for work, but roadmaps for improvement. We will continue to follow that map, because our water security relies on it. After meeting for two days with the federal and state agencies working on this project, we are confident that we can produce a good draft plan and EIS for the public to review, and that all the issues raised in the comments can be successfully resolved in the coming months."

The comment memos outline areas in the Admin Draft that may need further consideration. The release of this information is part of an ongoing and unprecedented effort to promote an open and transparent environmental review process for BDCP, a habitat conservation plan under state and federal endangered species laws that is designed to improve habitat in the Bay-Delta ecosystem and improve water supply reliability for 25 million Californians.

The Admin Draft reflects the significant downsizing of the proposed conveyance project that occurred in 2012 in direct response to federal and state wildlife agency comments. That downsizing includes a reduction in the number of intakes from five to three, a reduction in the maximum diversion capacity from 15,000 to 9,000 cubic feet per second, and a change to gravity-flow tunnels that would not require pressurization and additional pumping plants to move water. The environmental documents also include additional commitments that provide mechanisms to address water quality concerns raised by local water districts. In response to comments from federal agencies, the draft environmental documents will be revised to include

additional modeling that further refines the analysis of sea level rise and climate change effects. The public draft EIR/EIS will reflect that work.

"We have made significant progress in improving the overall integrity and accuracy of these draft environmental documents in the last year," said DWR Director Mark Cowin. "Clearly, there is more work to be done, and our team has already taken up the challenge to improve and enhance these documents in order to meet the ambitious deadline agreed to by the Governor and Secretary of the Interior."

The Admin Draft reflects improvements in analysis to show geographic-specific impacts, additional mitigation measures, and environmental commitments that extend beyond the scope of required mitigation actions under CEQA. This Admin Draft will undergo further necessary revisions, based on comments received to date, as part of the ongoing development of the Public Review Draft EIR/EIS scheduled to be released in October 2013. State and federal lead agencies will open a formal public comment period and, as part of completing the process, respond in writing to all public comments that are received.

In addition to the federal lead agency comments, BDCP is also making available comments provided by federal cooperating agencies – the U.S. Environmental Protection Agency and the U.S. Army Corps of Engineers. Numerous state and local agencies are recognized as cooperating agencies under NEPA and responsible agencies under CEQA and have been actively involved in providing initial comments on the Admin Draft.

The EIR/EIS documents are available for review at www.baydeltaconservationplan.com.

July 5, 2013

U.S. Fish and Wildlife Service Staff BDCP ADEIS Review

NEPA provides for an analysis of the environmental effects of a proposed action and possible mitigation of potential harmful effects of such actions. As required, agencies are obligated to a range of reasonable alternatives in enough detail so that a reader can compare and contrast the environmental effects of the various alternatives. As a disclosure document, the ADEIS must provide adequate information to enable the decision maker to make an informed decision on any given alternative. This ADEIS has been designed to provide a *project specific* analysis of CM1 (water facility portion of BDCP) and *programmatic* analyses for the other 21 conservation measures.

The FWS believes that the draft BDCP ADEIS is insufficient at this time as a disclosure document and is not yet adequate in providing all information and analyses necessary for a decision-maker to make an informed choice between alternatives.

This document summarizes several key issue areas identified in our review. We have already provided a large number of specific comments via the comment form preferred by ICF, and a substantial number of red-line strikeout edits in the ADEIS chapters. We expect to provide additional edits between the date of this document and end of the review period on July 31st. Our review thus includes three forms of response. All three are important. Together, they identify issues that will need to be resolved before the plan and EIS are completed, provide an approach to resolving them, and in many cases provide the actual edits that are needed. A subset of the issues we have identified will need to be resolved before the public draft is released. We look forward to working with DWR on resolving BDCP and DEIS issues as we move forward.

Issue Area 1: The ADEIS contains analysis and language that can be read as biased, favoring the preferred project; furthermore, it relies on similar analysis and language in the BDCP that has not yet been rectified.

Our April 2013 staff progress assessment of the BDCP (see Appendix) identified several factual errors and significant analytical defects in Chapters 3 and 5. All of the outstanding issues we identified in our April 2013 progress assessment of the BDCP are issues for this document as well. The key issues in the BDCP should be resolved, and the resolution propagated into the DEIS. In addition to factual and analytical errors, in certain cases ICF has treated the scientific information it presents unevenly, elevating information that is favorable to the preferred outcome and disparaging information that does not support it. Information and analysis used in the HCP and ADEIS should be presented in a neutral, even-handed way. Where necessary, the analysis in the BDCP should be edited in both substance and tone.

The Service has provided red-line strikeout edits to key sections of both documents to aid in making these corrections, and is prepared to work with DWR and ICF to ensure that other instances of these flaws are corrected. These fixes are important to the characterization and disclosure of the potential effects of the BDCP and its alternatives.

Both the language and the content of the ADEIS advocate for the CEQA proposed project. The language should be more neutral to meet the regulatory requirement of a “full and fair discussion of significant environmental impacts...” 42 CFR 1502.1.

The following examples illustrate the sort of advocacy language that should be avoided. The first quote is taken from a comparison of Alternative 1 to the NAA:

- While the effects on rearing habitat are potentially adverse, several conservation measures would reduce these effects to some extent. These measures include CM2 (Yolo Bypass Fisheries Enhancement), CM4 (Tidal Natural Communities Restoration), CM5 (Seasonally Inundated Floodplain Restoration), CM6 (Channel Margin Enhancement), and CM7 (Riparian Natural Community Restoration). This restoration would provide suitable spawning and rearing habitat adjacent to areas currently occupied by delta smelt. Assuming all the habitats restored under Alternative 1A are fully utilized by delta smelt, there would be minimal change (<5%) in the abiotic habitat index compared to NAA when averaged across water year types. [pg 1-11-172]*

The above quote was taken from a comparison of delta smelt fall habitat in Alternative 1 to the NAA, which had the higher modeled fall habitat suitability of the two alternatives. There are several word choices and phrases in this quote that we think represent unjustified advocacy language. The first instance is the use of the phrase “potentially adverse” to describe the model results. The modeling method is based on peer-reviewed science (Feyrer et al. 2011) and the FWS has already determined in its 2008 BiOp that higher fall X2 contributes to adverse modification of delta smelt’s Critical Habitat. The quote goes on to state that several conservation measures “would” offset the impact “to some extent”. Through its use of the word “would”, this claim overstates the certainty that habitat restoration would compensate for lower outflow, and “to some extent” is ambiguous. Measures CM2 and CM5 are floodplain actions, and Central Valley floodplains are generally upstream of areas smelt occupy in the winter and spring, and they are virtually never inundated during September-November. Thus, it is not clear how CM2 and CM5 could compensate the effects of for lower fall outflow through the mechanisms described. We agree that channel margin and riparian habitat improvements should improve overall riverine and terrestrial species habitat conditions in the Plan Area, and are good for migratory salmonids, but the implied linkage to delta smelt habitat is not supported. This is a comment that we also made in our comments on Chapter 3 of the HCP.

The various restoration strategies may increase spawning habitat for delta smelt, though as we noted in our HCP comments, this has not been effectively demonstrated through analysis – it has instead been assumed to occur. However, with regard to the quote above, delta smelt do not spawn in the fall, so it

is not relevant to the issue being analyzed whether or not restoration will increase the availability of spawning habitat: the issue is rearing habitat for *sub-adult* fish. Next, the analysis provides an alternative result based on a best possible assumption about the performance of habitat restoration in support of delta smelt rearing during fall. This might be appropriate if results based on more modest assumptions were also presented (without implying that the optimistic result is “better” or “more likely” than some other assumption), but this was not done. Last, the modeling of this best-case result generated predictions that fell within 5% of results for the NAA. However, as shown in Feyrer et al. (2011), the relationship between X2 and delta smelt’s fall habitat index is sigmoidal, with important thresholds. The thresholds mean that some 5% differences matter more than others, so absent the consideration of those thresholds, the result may be misleading even if the reader accepts its foundational assumption that 100% of restored habitats are useful and utilizable by delta smelt.

- *Average Delta outflow under Scenario H3 would be similar (<10% difference) to NAA in all months from January-June, except for April, when outflows would be 11% lower averaged for all years and 17% lower in above normal years. Under Scenario H1, Delta outflows would be similar between to baseline conditions during all months of the longfin smelt rearing period, except April when flows would be 10% lower. Under Scenario H4, April outflow would be increased and overall winter-spring flows would be similar (<10% difference) to NAA. [pg 3-11-16]*
- *Although there may be small decreases in estimated longfin smelt abundance indices, the predicted reductions would be minor and do not take into account the potential benefit of habitat restoration. Once larval smelt reach rearing habitat in the west Delta and Suisun Bay, they would likely benefit from habitat restoration actions (CM2, CM4, CM5, CM 6, and CM7), which would provide additional food production and export to longfin smelt rearing areas. [pg 3-11-18]*

The above quotes come from an assessment of Delta outflow during winter and spring as it pertains to longfin smelt. The assessment starts with a statement that < 10% differences in Delta outflow among scenarios are “similar”. Given the documented importance of spring flows to native California fishes (Meng et al. 1994; May and Brown 2002; Moyle 2002) and how much spring outflows have already been impaired by surface water development in the Bay-Delta watershed (Kimmerer 2002), a 10% (or nearly 10% reduction) could be important to the viability of the covered fish species. The quote goes on to report even larger outflow reductions in April of some water-year types and sub-alternatives.

Despite the “similar” modeled Delta outflow results, the biological models for longfin smelt that were applied to these modeled flow results predicted declines in longfin smelt abundance (Stevens and Miller 1983; Jassby et al. 1995; Rosenfield and Baxter 2007; Thomson et al. 2010). Rather than simply reporting these results, it was concluded that the predicted declines were “minor”. The Service recently determined that longfin smelt is warranted for listing under the ESA. Any additional threats or further declines in the status of the species must be evaluated carefully. Then, it is implied, as it was in the delta smelt example, that habitat restoration is a solution. Some of the proposed habitat restoration

may positively benefit longfin smelt; however what this sentence should say is that to succeed, Alt 4 management alternatives H1 and H3 would need to rely on a greater contribution from habitat restoration on longfin smelt than H2 or the proposed ("high outflow scenario") operations to compensate for the predicted lower abundance caused by lower modeled Delta outflow. We agree that CMs 2 and 4 can plausibly contribute to longfin smelt given the timing of their reproduction and their primary distribution in the estuary; however, the implied linkages of the other CMs are unsupportable, as we noted in our comments on Chapter 3 of the HCP. Further, if CMs 2 and 4 were to improve conditions for longfin smelt, it would not be in Suisun Bay, it would be in the ROAs themselves; the implication that restored habitats "would" provide a food subsidy to the open water bays in which most longfin smelt rear, is not currently supportable based on available scientific information and should be qualified as substantially uncertain.

ICF had previously proposed that model outputs that differ by $\leq 5\%$ would not be considered to represent real differences. We have previously advised the consultants that this was not a reliable way to screen or compare results because there might be a few instances (e.g., water temperature in the Sacramento River) where a 5% increase could be extremely problematic, but much more often there would be situations where large percent differences may be meaningless (e.g., predicted ag diversion entrainment increasing 300% from 0.001% of particles lost to 0.004%). Our advice was (and is) to define a biologically appropriate threshold difference for each metric and to use it consistently. As is evident in several of the quotes pasted above, the draft document frequently discounts differences in flow metrics as "similar" at levels of 10% or more which may nevertheless reflect model results that are different enough to be of concern (e.g., when they lead to predictions of lower longfin smelt abundance in some Alternatives and sub-Alternatives). We request again that ICF refrain from attempting to use a "one size fits all" percentage difference and subjective comparison terms (e.g., "similar") to describe numerically different thresholds. We would prefer if the data were simply reported using neutral, simple statements e.g., "Delta outflow would be X% lower in [condition] in Alternative Y vs. Z. It is concluded that this change would/would not be adverse."

Issue Area 2: The ADEIS is Missing a Clear, Full and Complete Project Description of the Proposed Action and Detailed Information Needed to do a Complete Project Specific Level Impact Analysis for CM1. Additionally, the ADEIS does not Provide an Equal Level of Analysis of All Alternatives.

2.1 The ADEIS does not address structural issues raised in our review of the BDCP

The ADEIS does not address issues raised in Issue Area 6 of our April 2013 progress assessment of the BDCP. In particular, it does not resolve the role of adaptive limits, or limits on the adjustment of water operations and habitat restoration conservation measures, that would be permissible through the action of adaptive management over the term of the permit. The alternatives considered in the ADEIS cover a wide range of Delta flows and other parameters, but absent explicit adaptive limits it is unclear what portion of those ranges would be the responsibility of the permit-holder(s), and unclear how the

potential implications of those ranges for achievement of plan biological objectives over the term of the permit should be evaluated.

2.2 The ADEIS should be edited to reflect agreement that the “high outflow scenario” version of Alternative 4 will be proposed as the initial BDCP operations

The description and analysis of alternative 4 (Proposed Action) should reflect agreement that the “high outflow scenario” version of CM1 will be proposed to be permitted as the initial BDCP operations. The description should reflect that the lower-outflow “decision tree” alternatives are being developed in the plan as management alternatives to be investigated through a focused adaptive management program. It should also reflect that a comprehensive review of new findings, including an assessment of habitat restoration effectiveness to date, will be conducted immediately prior to commencement of CM1 operations. That review will inform a new determination of outflow criteria that are sufficient to meet the plan’s biological objectives for covered fish species. In addition to changes to the ADEIS, changes to the BDCP are needed to implement this agreement, and should be made.

2.3 Incomplete Project Description

The ADEIS will need a clear and concise project-level description of the water conveyance facilities (CM1 – Proposed Action and 15 alternatives), including a description of the physical, chemical, and biological changes resulting from CM1. As mentioned above, the proposed operations and management alternatives for future investigation have not been adequately described.

The FWS recognizes current project definitions are changing, including the size of the forebay, power line placement, and the terrestrial species impact analyses. This new information when finalized will need to be revised for each of the alternatives and re-analyzed. In addition, the information currently provided in the ADEIS does not align with the most recent version of terrestrial effects in the BDCP HCP and will need to be updated.

Since the size of the forebay and power line placement has not been finalized, a complete and accurate project-level analysis of impacts is not included in the ADEIS. This is a concern for addressing impacts from the conveyance facilities on the Stone Lakes National Wildlife Refuge (SLNWR). The applicant had not been closely coordinating with the SLNWR until very recently. The SLNWR has been provided general and limited information over the past few years, which has made it challenging to evaluate and provide informed constructive comments to address project-level, site-specific impacts to the SLNWR and its associated wildlife. For instance, the FWS is still unclear about the exact size, routing and need for above-ground transmission lines and whether transmission could be placed underground to minimize strike impacts to migratory birds. It is also not clear if tunnel muck material temporarily deposited on wildlife compatible farmland will be suitable to use for growing similar crops.

There does not appear to be a complete project-level analysis that identifies mitigation for CM1 components for the 15 alternatives in the ADEIS. Until all the changes to the construction footprints have been finalized, additional minimization and mitigation measures may be necessary especially for

localized impacts including effects to terrestrial biological resources that use the SLNWR. The target acreages defined within the BDCP conservation strategy have been carried over into many of the ADEIS alternatives. However, there may be some instances where impacts from the CM1 components may require additional mitigation measures in the ADEIS from what is identified in the BDCP conservation strategy due to differences in the conveyance option footprints from the tunnel alignment identified in the HCP. For instance, impacts to the White Slough giant garter snake (GGS) population along the eastern Delta associated with the eastern alignment alternatives may warrant different mitigation than is currently identified in the BDCP conservation strategy, which includes mitigation for the tunnel alignment and conservation for the species. The FWS recommends that the ADEIS team work with the agencies to develop adequate minimization and mitigation measures for all alternatives under analysis. Since much of this information does exist in the terrestrial Conservation Strategy associated with the BDCP HCP, we recommend referencing that information in the ADEIS.

To meet the FWS's needs, the CM1 project level alternative information must be broken down into specific components such as: project footprint, storage areas, avoidance areas, stockpiling and borrow areas, work windows, waste sites, construction access, dust, construction equipment and techniques, erosion and sedimentation controls, construction of cofferdams, dredging, placement of rip-rap, operations & maintenance (*e.g.*, noise, lighting), vegetation clearing, staging and laydown areas, permanent vs. temporary impacts, duration of "temporary" impacts, etc.

2.4 Alternative Comparisons - Incorrect and/or Insufficient Information and Analyses

The ADEIS does not provide a sufficient and equal level of information and analysis of the Proposed Action and alternatives. As a result, many of the impacts of some alternatives weren't completely identified, resulting in unequal treatment in alternative analysis and comparison. Our key concerns are outlined below:

- As a result of combining programmatic and project-level alternative definitions and analyses in the DEIS, it's not apparent that either was provided completely or correctly.
- The No Action Alternative is not fully defined in Chapter 3, is internally inconsistent in Appendix 3D and is inconsistent with discussions in Chapter 5.
- Alternative 4 is not completely described or analyzed. There are pieces of definitions scattered in the document but no single compiled location. Alternative 4, Scenario 3 has been completely omitted from the analyses. In other areas of the document there is a tendency to point to the results of other alternatives as a surrogate for a complete analysis of alternative 4 and its four scenarios.
- Alternatives 1-9 and the No Action Alternative are not clearly nor completely defined in Chapter 3. Chapter 3 contains numerous cross-references between components of alternatives that are not completely comparable (*e.g.*, incomplete information or use of 5 intakes as a surrogate in explanations for alternatives with less than 5 intakes, etc.). The alternative component tables in Chapter 3 should be provided for all alternatives. The DEIS contains scattered alternatives

definitions throughout; however, no single location exists where each alternative is fully described and compared to other alternatives.

- Alternatives are not evaluated completely or adequately. When analyzing an alternative there were typically multiple references to the results of analysis of other alternatives. These other alternative analyses were at times only marginally comparable to the alternative being evaluated, and in some cases did not seem to be comparable at all (oversimplification of analysis). For example, tables in Appendix 12E with conveyance-related terrestrial impact information do not explain how that information relates to the components of alternatives, are not complete for all alternatives and do not match the same results found in Chapter 3 or Appendix 12D.

2.5 Aquatic Questions of Primary Importance to Address

The document does not include an “equal level” of analysis for all the alternatives. Because CM1 is intended to reflect a project specific level of analysis in the ADEIS, there are three questions that are of primary importance to the covered aquatic species that need to be clearly and credibly answered: (1) How much does modeled Delta outflow change across alternatives for each month of the year? (2) How much total entrainment (south Delta + north Delta + NBA + in-Delta ag) of delta smelt, longfin smelt, and splittail are expected in each of the alternatives? (3) How much Yolo Bypass flooding (in acre-days) is expected in each of the alternatives? We have provided guidance below as to how to promptly and effectively answer these questions, and we look forward to working with our partners to bring these technical summary issues to resolution in time for their inclusion in an executive summary.

The data to answer question 1 should be available from existing modeling. We suggest that the best method of summarizing and presenting the results would be to generate twelve exceedance plots for Delta outflow (one for each month); each plot would have a line depicting the exceedance curve for the NAA and a line depicting the exceedance curves for every alternative and subalternative that was modeled. This would provide the reader with a clear visual summary of results for one of the key habitat attributes of the estuary that is potentially affected by variations in CM1. Delta outflow provides a different suite of mechanistic contributions to fish habitat that varies each month of the year (Jassby et al. 1995; Kimmerer 2002; Feyrer et al. 2011). Results based on these published studies should be reported.

The primary rationale for including CM1 as a conservation measure rather than only as an element of the Project Description was that south Delta export operations would be structured to reduce the entrainment of covered fish species below what is expected with current water project geometry under the current RPAs. The plan includes numerical entrainment Objectives that CM1 is designed to achieve in order to contribute to longfin smelt and delta smelt recovery. The ADEIS needs to clearly and credibly show whether or not these outcomes would be achieved. The draft ADEIS reports some south Delta entrainment results, but it does not provide an equal level of analysis everywhere. Further, it does not provide a clear, quantitative synthesis across *all sources of fish entrainment* (a blend of CM1, CM4, and CM21) across *all alternatives*. This can and should be done using existing modeling by (1) using existing

south Delta entrainment estimates derived through the methods discussed in BDCP technical appendices; (2) estimating ag diversion entrainment as a function of modeled E:I ratios using the DSM2-based relationship shown in Kimmerer and Nobriga (2008) and including a reasonable range of reductions expected from decommissioning diversions as part of CM4 and CM21; (3) making a range of reasonable assumptions about entrainment/impingement loss of delta smelt, longfin smelt, and splittail at the proposed north Delta intakes; and (4) incorporating a range of reasonable assumptions about entrainment/impingement at the existing and proposed NBA intakes. The resulting estimates of total entrainment should then be summarized using exceedance curves as described above for Delta outflow – with the exception that seasonal summaries rather than monthly summaries are appropriate.

The third question reflects our continued uncertainty about the cumulative Yolo Bypass results (meaning the blend of CM1 and CM2). The modeling exists to report Yolo Bypass inundation results in summed “acre-days” meaning acres flooded times the number of days the acreage remains flooded. This is critical because flooded acreage can change up to 100% per day (Sommer et al. 2004). Table 11-4-74 indicates an increase in acres flooded, but Table 11-4-73 indicates some potential trade-offs in the duration of inundation events duration among water year types. The best way to present differences in Yolo Bypass inundation across alternatives for the benefit of a reader of the ADEIS is to generate monthly exceedance plots of acre-days of Yolo Bypass flooding in a manner analogous to what we outlined above for presenting Delta outflow results.

2.6 New Information and/or Analysis to Include in the Project Description

A new diversion is identified in CM1 that would provide Sacramento River water to Solano County. This new diversion would augment supplies diverted at the existing Barker Slough facility. However, there is no clear explanation of how both diversions would be operated to minimize species impacts or to maximize water supply benefits to associated SWP contract quantities. Since many BDCP conservation measures are being designed to increase habitat values for covered species in the northern Delta, there is a need to evaluate whether continued operations at Barker Slough will have new detrimental impacts to listed aquatic species.

It is our understanding that continued long-term operation of the Suisun Marsh Salinity Control Structure (SMSCS) will be an on-going requirement for the SMPA and OCAP agreements. We are also of the understanding that the SMSCS is not represented in any of the hydrologic modeling that has been used to date to evaluate the effects of the projects or of any models used to compare operational scenarios (other than the NAA). The FWS will require an analysis that accurately represents the effect of the SMSCS since this structure, when operated, can have impacts to salinities and flows in the western Delta and Suisun Marsh that will affect project operations and the meeting of water quality standards in the Marsh.

Issue Area 3: The ADEIS is subjective in how it reports model outputs and makes comparisons against the NAA and across alternatives.

3.1. It will be necessary for the BDCP Effects Analysis tools to be chosen or constructed in a way that the differences between scenarios be detectable using those tools. Since we still do not have a sensitivity analysis for the BDCP Effects Analysis tools suite, we cannot say with confidence what the accuracy or precision of the analysis methods are. Until we know how sensitive our tools are we cannot know if the Effects Analysis will accurately depict a difference between alternatives, will be unable to resolve differences between alternatives (thus rendering all alternatives “equal”), or will be so sensitive that even similar alternatives will be judged vastly different. We suggest that the simplified schematic that depicts how each model has been used in relation to other models within the analysis that is shown in the plan technical appendix also be included in the ADEIS with the following addition. As part of this schematic, an estimate of the relative or absolute error should be depicted, and an overall sum or other mathematical accumulation of error estimate should be included.

3.2. The ADEIS Modeling Technical Appendix 5A must include Section D. This section is intended to be a compilation of detailed information that describes the development of the analytical tools, the limitations and uncertainty in the analytical approach, additional details on the components of the analytical tools, background information on climate change modeling and any sensitivity analyses performed in support of the overall analysis. There are numerous sensitivity studies that may have been done related to the various non-hydrologic models. Appendix 5A Section D is where all the caveats and justifications should be housed, so the reader can judge the value of the modeling upon which much of the effects analyses rests. This information is critical to the defensibility and transparency of the foundational modeling, and should be included in the ADEIS.

3.3. Section D should provide information that justifies or provides rationale for the following assumptions that are used for the hydrological analysis in the DEIS, including:

1. Why demands for water will not increase state-wide between 2020 and 2060.
2. Why given the significant effects of sea level rise and climate change, there will be no change in cropping patterns, water use efficiency, reservoir flood control diagrams, relaxations in regulatory standards during critically dry periods. Why, in essence, there will be no adaptation to sea level rise and climate change.
3. Representation of export operations with a monthly timestep, particularly when comparing NAA to ALT6.
4. The additional effects of daily variability are not significant when compared to the monthly time-step values for CALSIM within Alternatives.

Issue Area 4: Significant Water Quality Conflicts Exist for Restoration-Related Conservation Measures

4.1. Managing legacy mercury and selenium is a challenge in the Delta, particularly within wetland habitats where physical conditions tend to increase the bioavailability of these contaminants to fish, wildlife and humans. Restoration sites will be chosen to maximize the likelihood that they will contribute

to covered species needs but many sites will also overlay areas of the Delta with higher mercury deposition (e.g. Yolo, Cosumnes). Human health and drinking water criteria are the principal drivers in managing Delta contaminants, especially mercury. BDCP has proposed to manage mercury and selenium in future restoration sites, unfortunately many of the tools available to minimize contaminant exposure directly conflict with the natural ecological processes of aquatic and wetland ecosystems. The following describe restoration water quality challenges and conflicts within the Conservation Measures.

Conservation Measure 12: Mercury Management. There is no indication that the kinds of habitat restoration that can meaningfully contribute to estuarine fish viability can be created or restored without also methylating the ubiquitous mercury in the system because the management tools available conflict with these fishes' habitat needs. Minimization of water depth and reduction of turbidity to control mercury methylation conflict with the direct habitat needs of delta and longfin smelt and will in some locations favor invasive species such as sunfishes and water hyacinth. However, minimization of water depth and turbidity will maximize the potential for algal production and algal production will generate dissolved organic carbon (DOC). If, as the ADEIS implies, restoration sites will also be designed to minimize the export of DOC from restoration sites to minimize anoxic conditions (reducing methylation opportunities) these designs will also reduce their potential food web benefits. The magnitude of the restoration proposed, the limitations of available modeling tools, variability of mercury concentrations within the Delta, and the complex biochemistry of mercury limit our ability to predict with reasonable confidence the resulting methylmercury conditions in large-scale habitat restoration. However, the plan does not identify this high level of uncertainty or adequately explain how this challenge will be addressed to meet BDCP biological goals and objectives.

Conservation Measure 4: Tidal Natural Communities Restoration. An expected increase in contribution of San Joaquin River water to the Delta will increase selenium loading in the Delta, especially in the southern Delta and Suisun Bay where bioaccumulation by bivalves is assured (Stewart et al. 2004). This in turn represents an increased risk of deleterious reproductive effects caused by selenium accumulation in fish and wildlife. As with mercury, the scale of the restoration, the variability of selenium concentrations within the Delta, limited modeling, high overbite clam biomass in Suisun Bay, and delayed TMDL compliance limit our ability to predict selenium conditions in large-scale habitat restoration and the potential for its propagation through the food web. The ADEIS does not explain how this challenge will be addressed to meet BDCP biological goals and objectives.

Turbidity inconsistency between ADEIS and HCP. Planned management of turbidity within the HCP and ADEIS is inconsistent. NEPA Alternative 4, "Impact WQ-30: Effects of turbidity from CM2-CM22" states that total suspended solids and turbidity levels in the affected channels will not be substantially different from levels under Existing Conditions or the No Action Alternative. This contradicts the claim made by CM4 that wind resuspension in shallow, tidal wetland will increase turbidity and benefit native estuarine fishes and the conclusion (in Chapter 5 of the plan) that the NDDs would remove 8-9% of the Sacramento River sediment supply. It is not credible to claim that BDCP can simultaneously maintain

the status quo, increase turbidity within the Delta for estuarine fishes with CM4 while reducing turbidity at restoration sites to improve photodegradation of methylmercury.

4.2. Water quality mitigation conflicts within the ADEIS/EIR for drinking water

The ADEIS fails to relate the concomitant effects of the use of restoration sites for drinking water mitigation to the overall benefit of the Conservation Measures to covered species. In addition to the restoration water quality conflicts and challenges that occur in the HCP, mitigation of two water quality parameters for drinking water directly conflict with covered species habitat needs in the ADEIS. Due to existing Delta conditions there is no “assimilative capacity,” or room to increase concentrations, and still meet Delta beneficial uses for, selenium and mercury. The following are descriptions of these conflicts. Dissolved Organic Carbon (DOC): “Alternative 4, Mitigation Measure WQ-18 (p. 8-442)” proposes to reduce DOC, by designing wetlands to decrease “net Delta loading,” thereby reducing the concentration of disinfection byproducts for drinking water. Irrespective of the fate of that carbon, it does not seem feasible that 65,000 acres of tidal habitats could be restored for the purpose of enhancing the estuarine food web without increasing the production of organic carbon of all size fractions. The HCP’s purported benefit of habitat restoration is an increase in primary productivity, which is itself a source of organic carbon as well as the base of the food web for covered species (BDCP, Chapter 5.4, 5.5, et al.). Thus, reductions in DOC within or from restoration sites to improve drinking water quality would reduce the potential ecological benefit upon which BDCP aquatic habitat restoration is premised.

Selenium: Alternative 4, Mitigation Measure WQ-26 (p. 8-431-463) includes three approaches to reduce selenium to meet drinking water criteria. These approaches include the sequestration of selenium at restoration sites using surface flow treatment wetlands, reducing organic matter and associated anoxic aquatic conditions to reduce selenium bioavailability, and managing water and vegetation to reduce concentrations and bioavailability. Sequestration of selenium in wetlands would result in an unquantifiable increase in bioaccumulation and exposure to fish and wildlife. Management of wetlands to exclude birds would be infeasible and negate an essential benefit of habitat provided by the restoration. DOC reductions are undesirable for reasons previously stated and managing vegetation and water levels are not practical for most tidal and flood-prone restoration sites, especially those connected to open channels. The ADEIS does not specify if acreages used as surface flow treatment wetlands will be counted as part of the restoration committed in CM2-CM6 or in addition to the 85,000+ acres planned.

The Service requests the following:

- Describe the uncertainty of methylmercury and selenium analysis, effects and management for CM2-CM6.
- Provide details of how CM12 will manage methylmercury among the conflicting needs of covered species, ecosystem restoration and human health within the context of high uncertainty.
- Explain how BDCP CM2-CM6 will provide the purported increase in habitat area for covered species and the ecological services that would be provided by restoration in light of the

uncertainty with mercury methylation and selenium accumulation. If restoration sites produce untenable concentrations of mercury or selenium, how will the Conservation Measures adapt? How will restoration goals and the biological objectives of the plan that depend on restoration be achieved? If restoration areas are used for drinking water mitigation, how will compensation occur to ensure that the ecological services and habitat area commitments for covered species are met?

- Correct inconsistencies and conflicts within and between the BDCP and the NEPA document (e.g. NEPA conclusion that turbidity will not change from the Existing Condition but BDCP claims a benefit of wind suspended sediment for delta smelt in the and Conservation Measure 4 (BDCP 3.4-108)).

Issue Area 5: Inconsistencies in the ADEIS with the HCP, lack of a qualitative discussion of the effects, and need for greater incorporation by reference of the HCP into the ADEIS.

5.1. Inconsistencies between the HCP and DEIS were found in the species life history and habitat criteria descriptions, methods, and effects analysis approach. The ADEIS uses a different method for determining beneficial effects of the Alternatives than was used for terrestrial species in the HCP. The methods section does not accurately reflect the methods that were used in the current draft of the ADEIS, e.g., Page 1—12, lines 37-39, incorrectly states that the ADEIS analysis of the environmental consequences for terrestrial species uses the same methods as the HCP. The FWS recommends that the ADEIS adopt the terrestrial species account descriptions, methods, and effects analysis approach used for analyzing and reporting effects to terrestrial species that the FWS and consultants developed while drafting the HCP. Given the differences between alternatives, this will need to be augmented as appropriate.

The approach taken for reporting terrestrial species effects for all Alternatives does not provide an adequate description of all of their impacts and focuses primarily on quantitative analysis. The document lacks the necessary broader analysis that will require a qualitative assessment of the effects consistently for all the Alternatives. In order to improve the effects analysis, refer to the approach the HCP has taken for reporting qualitative effects which includes consideration of connectivity, fragmentation, size, heterogeneity, buffers from sources of mortality, and proximity to other protected areas. For those Alternatives that share similar effects, the FWS recommends incorporating the HCP by reference into the ADEIS. For the remaining dissimilar Alternatives, the EIS team will need to determine what qualitative analyses will be necessary and then complete those analyses for each Alternative to attain equal level of detail.

5.2. Inconsistencies exist in the species life history and habitat criteria descriptions. For instance, the ADEIS considers “developed” lands to be a “natural community type” in Table 12-1, which is inconsistent with the HCP. For example, Table 12-2 (page Part 1 12-25 through Part 1 12.-35) of the ADEIS indicates developed lands are habitat for giant garter snake, but Table 3.3-3 (page 3.3-89 through 3.3-91) of the

HCP does not. The Service recommends a full QA/QC to assure that the species life history and habitat criteria descriptions in the ADEIS match those in the HCP. If developed lands were included in the habitat suitability models for GGS and other terrestrial species, they will need to be updated to be consistent with the models used in the HCP.

Another example of inconsistencies between the HCP and the ADEIS relates to their treatment of GGS impacts in the Yolo Bypass (Impact BIO-49 (Part 1-12-242)). The ADEIS current description of impacts only reports the modeled habitat overlay results (impact numbers). It does not provide a more complete evaluation that would include the qualitative analysis of flooding impacts that was included in the HCP. In addition, the HCP updated its analysis of impacts to rice production in the Yolo Bypass and its commitment to rice conservation, which benefits GGS. This updated information needs to be included in the ADEIS. For Alternatives that are not sufficiently similar in their project description to the HCP, the EIS team still needs to estimate those impacts and report them for each Alternative at an equal level of detail.

As a final example of inadequate analysis, there is no evaluation of the additional impacts of the eastern alignment to the White Slough population of GGS. The canal could impact the viability of that population by removing its ability to distribute within its habitat and connect to other populations. As with other analytical issues, this impact needs to be analyzed across Alternatives, at an equal level of detail.

Issue Area 6: Cumulative Effects Analysis.

6.1. The terrestrial biological resources cumulative effects section 12.3.3.17 needs to include a greater discussion of a reasonable analysis of the significant cumulative impacts. The ADEIS should incorporate a more robust discussion on the past, present, and reasonably foreseeable actions within this section. Section 12.3.3.18 of the DEIS contains a very robust discussion of the effects of the other surrounding conservation plans. The remainder of the programs, projects, and policies in Table 12-6 need to be addressed at a similar level of detail. It is also unclear to the Service how the larger list of programs, projects, and policies were condensed to the list reported in Table 12-6. The FWS would like to meet with the ICF ADEIS consultants and develop an approach to dealing with the cumulative impacts in the ADEIS document. Looking at example sections for NEPA documents from other conservation plans in northern California dealing with similar past, present, and reasonably foreseeable actions could serve as a starting point in the discussion.

Issue Area 7: The ADEIS Does Not Meet the Readability Test Under NEPA.

7.1. In order to adequately inform a decision-maker and the public under NEPA, an EIS needs to identify and analyze differences between the alternatives (e.g., why is one better than another?) by clearly and

independently defining the alternatives, their impacts and benefits, and providing comparisons for the reader in a “readable” fashion. 42 CFR 1502.8 requires that EIS’s be written in plain language. In addition, CEQ regulations state that agencies “shall reduce paperwork and the accumulation of extraneous background data”.

The ADEIS is very difficult to read. Without clear and complete descriptions of the Proposed Action and its alternatives, the reader does not have the ability to review and compare the Proposed Action and its reasonable alternatives as compared to the NAA. The alternative definitions and analyses are long and the methods and analyses used to define, display and analyze alternatives have resulted in a very difficult document to navigate and comprehend. Oversimplification of analysis through numerous instances of the cross-referencing of marginally-comparable analyses has contributed to the unequal analysis of alternatives in the ADEIS.

More effort should be provided to simplify, summarize and provide complete descriptions and analyses of alternatives, including providing a separate section that allows for comparison of each of the project-level CM1 alternatives. Combining the NEPA and CDEQA analyses makes the document difficult to follow, affecting its readability. We recommend separating the NEPA and CEQA information into separate sections of the ADEIS. This will help provide the necessary additional clarity for the reader.

END

District Workshop

Bay Delta Conservation Plan

&

**Delta Habitat Conservation & Conveyance
Program**

2013 Nov 20



BDCP1563.

2013 Nov 20
Subject: Bay Delta

3d. Risks Affecting Assumptions:

Illustration: Partial levee failure as TBM passed underneath

Project: SFPUC's Bay-Division Tunnel,
Levee at Cargill Salt Pond
Newark CA

Date: 2012 Aug (Dutra)

**~ 100 ft. = Depth
to Tunnel**



2013 Nov 20 Draft
Subject to Revision



Characterization of disinfection byproduct formation potential in 13 source waters in China

Junzhi Zhang¹, Jianwei Yu¹, Wei An¹, Juan Liu¹, Yongjing Wang¹,
Youjun Chen², Jia Tai², Min Yang^{1,*}

*1. State Key Laboratory of Environmental Aquatic Chemistry, Research Center for Eco-Environmental Sciences,
Chinese Academy of Sciences, Beijing 100085, China. E-mail: junzhiz@126.com*

2. Beijing Waterworks Group, Beijing 100065, China

Received 23 March 2010; revised 15 May 2010; accepted 09 June 2010

Abstract

The formation potential of four trihalomethanes (THMFP) and seven haloacetic acids (HAA₇FP) in 13 source waters taken from four major water basin areas in China was evaluated using the simulated distribution system (SDS) chlorination method. The specific ultraviolet absorbance (SUVA₂₅₄: the ratio of UV₂₅₄ to dissolved organic carbon (DOC)), which ranged between 0.9 and 5.0 L/(mg·m), showed that the organic compounds in different source waters exhibited different reactivities with chlorine. The HAA₇FP of source waters ranged from 20 to 448 µg/L and the THMFP ranged from 29 to 259 µg/L. The HAA₇FP concentrations were higher than the THMFP concentrations in all but one of the samples. Therefore, the risks of haloacetic acids (HAAs) should be of concern in some source waters. TCM (chloroform) and BDCM (bromodichloromethane) were the major THM constituents, while TCAA (trichloroacetic acid) and DCAA (dichloroacetic acid) were the major HAA species. Br-THM (brominated THM species) were much higher than Br-HAA (brominated HAA species), and the formation of Br-DBP (Br-THM and Br-HAA) should be of concern when the bromide concentration is over 100 µg/L.

Key words: disinfection byproduct formation potential; trihalomethanes; haloacetic acids; bromine substitute factor

DOI: 10.1016/S1001-0742(10)60440-8

Citation: Zhang J Z, Yu J W, An W, Liu J, Wang Y J, Chen Y J et al., 2011. Characterization of disinfection byproduct formation potential in 13 source waters in China. *Journal of Environmental Sciences*, 23(2): 183–188

Introduction

Natural organic matters (NOMs) not only cause color, taste and odor in drinking water (Hargreaves and Watson, 1996; Sagehashi et al., 2005), but are also the precursors of disinfection byproducts (DBPs), such as trihalomethanes (THMs) and haloacetic acids (HAAs) (Chow et al., 2008; White et al., 2003; Wong et al., 2005), which have adverse health effects (Hanson and Solomon, 2004; Jung and Son, 2008). When source water contains bromide, bromine substitution occurs during chlorine disinfection because chlorine can quickly oxidize bromide to hypobromous acid (HOBr) (Pourmoghaddas and Stevens, 1995; Richardson et al., 2003). HOBr has a better activity than hypochlorous acid (HOCl) as a halogenating agent (Nokes et al., 1999), and brominated-DBPs have caused increasing concern due to their strong carcinogenic effects (Huang et al., 2004; Zhang et al., 2008). Considerable effort has been devoted to the characterization in DBPFP of source water since it is well known that source water quality has a significant influence on the design and

operation of water treatment processes (Chang and Singer, 1991). It was found that the characteristics of DBPFP in drinking water sources depend largely on the geological conditions and the surrounding watersheds (Ates et al., 2007a; Guo et al., 2006; Kim, 2009; Richardson et al., 2003; White et al., 2003; Ye et al., 2009). Despite attempt to characterize NOM in several source waters (Wei et al., 2008; Yan et al., 2006), the characteristics of DBPFPs in source water in China, particularly HAAFPs, have not yet been systematically investigated.

In this study, the formation potential of four trihalomethanes (THMFP) and seven haloacetic acids (HAA₇FP) in 13 source waters in China was evaluated using the simulated distribution system (SDS) chlorination method. The impact of bromide content on the formation of brominated-DBP (Br-DBP) was also investigated. The results of this study may provide a basis for the selection of water purification processes and disinfection strategies.

1 Materials and analytical methods

1.1 Water sample collection and storage

Thirteen source water samples were collected from water supply sources in eight cities from the northeast to south China covering five of the seven major water Basin areas (Songhua River Basin, Hai River Basin, Yangtze River Basin and Huai River Basin). Seven samples were collected from reservoirs (R2–R7, R12), five from rivers (R1, R9–R11, R13), and one from a lake (R8).

The samples were collected from April to December, 2009. To ensure consistency of results, all water samples were stored at 4°C after collection until use, and were taken out no less than 8 hr before sample analyses and treatment experiments.

1.2 Chlorination of samples

The procedures for simulated distribution system (SDS) chlorination were based on the method suggested by Koch et al. (1991). The Cl_2 -demand (Cl_2D) of each sample was confirmed according to the standard method (APHA, 1995) prior to the experiments. The volume of HCl (0.1 mol/L) or NaOH (0.1 mol/L) necessary to adjust the pH to 7.0 ± 0.2 was recorded before the experiments. The samples were chlorinated at $\text{pH } 7.0 \pm 0.2$ in 10-mL borosilicate vials, with a nonstick coating-lined septum and screw caps, with sufficient chlorine to provide a free chlorine residual of 1.0 ± 0.4 mg/L after storage at $(25 \pm 1)^\circ\text{C}$ for (24 ± 1) hr. Phosphate was used to buffer the solution at pH 7. Analyses of THMs and HAAs were then conducted after residual chlorine was quenched with L-ascorbic acid.

1.3 Parameter definition

The bromine substitute factor (BSF, n and n' for THM and HAA, respectively) was defined as the molar ratio of bromine to the sum of chlorine and bromine in the targeted DBP (Chow et al., 2007). n or n' was equal to zero if pure chlorine DBPs were formed and was equal to 100% if pure brominated DBPs were produced.

For THM

$$n = \frac{\sum_{c=0}^3 c[\text{CHCl}_{(3-c)}\text{Br}_c]}{3 \sum_{c=0}^3 [\text{CHCl}_{(3-c)}\text{Br}_c]} \times 100\% \quad 0 \leq n \leq 100 \quad (1)$$

For HAA

$$n' = \frac{\sum_{c=0}^3 c[\text{C}_2\text{H}_2\text{O}_2\text{Cl}_b\text{Br}_c]}{(b+c) \sum_{c=0}^3 [\text{C}_2\text{H}_2\text{O}_2\text{Cl}_b\text{Br}_c]} \times 100\% \quad 0 \leq n' \leq 100 \quad (2)$$

($a+b+c=4$; $1 \leq b+c \leq 3$; $a=1, 2, 3$; $c=1, 2, 3$)

1.4 Water quality parameters

Dissolved organic carbon (DOC) was measured with a total organic carbon analyzer (Phoenix 8000, Tekmar-Dohrmann Co., USA). UV absorbance was measured at 254 nm with an ultraviolet-visible spectrophotometer (U-3100, Hitachi Co., Japan). The bromide ion (Br^-) concentration was measured with an ionic chromatograph

1.5 Trihalomethanes

Eight milliliter chlorinated samples were extracted by hexane and analyzed for trihalomethanes (THMs), including chloroform (TCM), bromodichloromethane (BDCM), dibromochloromethane (DBCM), and bromoform (TBM) using a gas chromatograph (Agilent 6890N Gas Chromatograph, USA) equipped with a fused silica capillary column (HP-5, 30 m, $320 \mu\text{m} \times 0.25 \mu\text{m}$) and an electron capture detector (ECD). The analysis of THMs was conducted according to the standard method 5710B and 6232B (APHA, 1995). Total trihalomethanes was the sum of the concentrations of TCM, BDCM, DBCM, and TBM.

1.6 Haloacetic acids

Two milliliter chlorinated samples were analyzed for seven haloacetic acids (HAAs): monochloroacetic acid (MCAA), dichloroacetic acid (DCAA), trichloroacetic acid (TCAA), bromoacetic acid (MBAA), dibromoacetic acid (DBAA), bromochloroacetic acid (BCAA), and bromodichloroacetic acid (BDCAA) on a UPLC-MS/MS (ACQUITY UPLC system, Waters, USA). HAA₇ was measured by UPLC-MS/MS. The details of the method are as follows. The separation was performed using an ACQUITY UPLC system with a BEH C8 column ($2.1 \text{ mm} \times 100 \text{ mm i.d.}, 1.7 \mu\text{m}$). The mobile phases were composed of 0.1% formic acid solution (eluent A) and 100% acetonitrile (eluent B). A linear mobile phase gradient which started at 5% eluent B and went to 50% eluent B in 4.0 min was followed by a linear gradient to 100% eluent B over 1.0 min (held for 1.0 min), and was concluded by column equilibration at initial conditions of 5% eluent B for 1.5 min, for a total run time of 7.5 min. The flow rate was 0.3 mL/min for all stages and the sample injection volume was 15 μL . Source temperature, desolvation temperature, the rate of desolvation gas and the cone gas were 110°C , 350°C , 800 L/hr and 50 L/hr, respectively. Detection was performed using an ACQUITY TQD tandem mass spectrometer operated in the electrospray ionization (ESI) negative-ion mode. The MRM transitions were: m/z 92.60/34.80, 126.60/82.60, 136.70/78.50, 160.60/116.60, 172.70/128.70, 206.80/162.60, and 216.80/172.80 for MCAA, DCAA, MBAA, TCAA, BCAA, BDCAA, and DBAA, respectively. HAA₇FP was the sum of the concentrations of the seven haloacetic acids.

2 Results and discussion

2.1 Source water characteristics

The characteristics of the source waters are shown in Table 1. DOC varied widely from 1.6 to 7.3 mg/L. SUVA (specific ultraviolet absorbance at 254 nm, the ratio of UV_{254} to DOC), an indicator of the aromaticity of NOM (Weishaar et al., 2003), varied between 0.9 and 5.0 L/(mg·m). The Cl_2 -demands (Cl_2D) varied widely from 0.9 (R7) to 22.9 mg/L (R8), showing that the organic compounds in different source waters exhibited different reactivities with chlorine. The Br^- concentration, on the

Table 1 Source water characteristics

Sample*	DOC (mg/L)	SUVA ₂₅₄ (L/(mg·m))	Br ⁻ (μg/L)	Br ⁻ /DOC (μg/mg)	Cl ₂ D (mg/L)	THMFP (μg/L)	HAA ₇ FP (μg/L)	THMFP/HAA ₇ FP
R1 (126°41'E, 45°45'N)	6.8	3.2	21	3.1	12.8	191	448	0.4
R2 (126°41'E, 45°45'N)	4.8	2.7	33	6.9	7.1	175	357	0.5
R3 (119°35'E, 39°55'N)	2.4	1.1	10	4.0	2.9	41	133	0.3
R4 (116°28'E, 39°54'N)	3.9	1.2	12	3.1	7.6	95	196	0.5
R5 (117°E, 36°38'N)	3.4	1.7	114	33.7	4.0	77	142	0.5
R6 (117°E, 36°38'N)	3.3	1.7	128	39.1	2.1	68	74	0.9
R7 (117°E, 36°38'N)	3.1	0.9	41	13.2	0.9	29	20	1.5
R8 (117°11'E, 34°15'N)	7.3	1.7	173	23.6	22.9	259	374	0.7
R9 (121°29'E, 31°14'N)	5.5	2.5	144	24.9	7.1	232	273	0.8
R10 (121°29'E, 31°14'N)	2.4	2.2	249	45.6	4.8	62	165	0.4
R11 (120°54'E, 30°64'N)	5.8	2.9	91	37.2	8.2	207	265	0.8
R12 (110°20'E, 20°02'N)	3.3	1.5	70	21.4	7.6	95	136	0.7
R13 (110°20'E, 20°02'N)	1.6	5.0	64	39.2	2.9	60	91	0.7

* pH of the 13 raw waters ranged from 6.7 to 8.3, only the pH of R13 was < 7.0.

In general, the reservoirs showed a lower Br⁻/DOC ratio than the rivers and lake (except R1).

2.2 Speciation of THMs and HAAs

In the 16 samples, THMFP ranged from 29 to 259 μg/L and HAA₇FP ranged from 20 to 448 μg/L (Table 1). It was found that, the ratio of THMFP to HAA₇FP was below 1.0, with the exception of R7, showing that most of the source waters had higher HAA₇FP values than THMFP values. For six source waters (R1–R5, R10), the ratio of THMFP/HAA₇FP was ≤ 0.5. The above results show that the risk of HAA was higher than THM in these areas, which is quite different from previous reports in other countries. Krasner et al. (1989) found that the level of HAAFP was only half that of THMFP in 35 water treatment facilities in the USA. Singer et al. (1995) found that THMFP was not less than HAAFP in North Carolina drinking waters. The mean THMFP/HAAFP ratio was 1.45:1 for 17 drinking water systems in Alaska (White et al., 2003). The hydrophobic acid (HoA) fraction in dissolved organic matter was found to contain major THM precursors in some Chinese surface waters (Wei et al., 2008). However, the hydrophilic acid (fulvic acid) fraction was found to contain primary precursors for THM and HAA in source water from Israel (Richardson et al., 2003). Therefore, further studies are needed to elucidate the relationship between DBPFP and these chemical structures.

THMFP and HAA₇FP were correlated with DOC ($R^2 = 0.76$, 0.83 , respectively) and UV₂₅₄ ($R^2 = 0.66$ and 0.78 , respectively), which was in accordance with previous studies (0.83 – 0.87 and ≥ 0.96) (White et al., 2003). The UV₂₅₄ group usually contains free electrons in oxygen and sulfur atoms, conjugated C=C double bonds and aromatic carbon (Chow et al., 2008). Thus, SUVA is often used as an indicator of the aromaticity of NOM (Weishaar et al., 2003), and is considered to be related to DBPFP (White et al., 2003). In this study the SUVA₂₅₄ was related to THMFP reactivity ($R^2 = 0.48$) and HAAFP reactivity ($R^2 = 0.28$). SCl₂D (the ratio of Cl₂-demand to DOC) is used to indicate the reactivity of organic carbon in water with chlorine, and is therefore related to DBPFP (Gang et al., 2002). The wide range in SUVA (0.9 – 5.0

L/(mg·m) and SCl₂D (0.3 – 3.1 mg/mg) showed that the reactivity of organic carbon in different source waters varied significantly.

2.3 Composition of THMFP and HAA₇FP

Figure 1 shows the distributions of THMFP and HAA₇FP in the 13 source waters. TCM (chloroform) was the major THMFP compound (34% – 94% , mean value was 62%), followed by BDCM (4% – 45% , mean value was 26%). With the exception of R7, these two species amounted to more than 80% of THMFP. On the other hand, TCAA and DCAA were the major HAAFP species (61% – 99%) except for R7. R7 only contained TCAA (52%) and DCAA (48%). It should be noted that in all 13 samples, MCAA and MBAA were below detection limit (2 μg/L). The dominance of multi-chlorine substituted species within DBPFPs is a commonly observed trend in the literature for natural waters with low bromide levels (Ates et al., 2007a).

2.4 Bromine substitute factor (n , n') and Br-DBP

During the chlorination process, Cl₂ or hypochlorous acid (HOCl) can oxidize bromide to hypobromous acid (HOBr), which is a stronger halogenating agent than chlorine (Heller et al., 1993; Nokes et al., 1999; Pourmoghaddas and Stevens, 1995). Therefore, the formation of brominated DBP species (Br-DBP) with higher toxicities than chlorinated DBP species (Sohn et al. 2006), becomes a concern for source waters containing high concentrations of bromide. It is believed that the bromide level in source waters is one of the most important factors affecting the formation of Br-DBP (Heller et al., 1993; Sohn et al., 2006; Sorlini and Collivignarelli, 2005). The impacts of bromide concentration on Br-DBP and BSF are shown in Fig. 2. It is clear that Br-DBP values for both THM and HAA were correlated with bromide concentration ($R^2 = 0.78$ and $R^2 = 0.74$, respectively). However, Br-THM was much higher than Br-HAA, which was also in accordance with previous studies (Oliver, 1980; Symons et al., 1993). It was found that Br-HAA was not perceptible at bromide levels < 50 μg/L, and gradually increased when the bromide concentration increased.

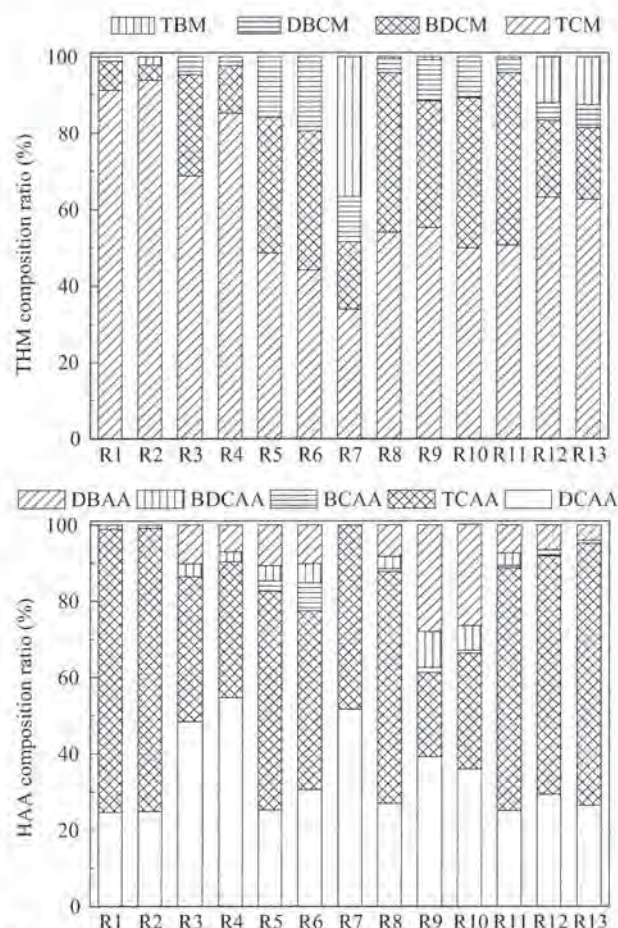


Fig. 1 Distribution of THMFP and HAA₇FP in raw waters. MCAA and MBAA were below the detection limit (2 µg/L).

Br-THM, on the other hand, was < 40 µg/L at a bromide level below 150 µg/L, but was then significantly increased to > 100 µg/L at higher bromide concentrations. It was also reported that bromide level effected Br-DBP in Italian and Alibeykoy natural waters (Ates et al., 2007b; Sorlini and Collivignarelli, 2005). When the bromide level increased from low bromide (< detection limit) to 500 µg/L, TCM decreased from 60% to 20% of THMs, and Br-THM increased from approximately 40% to more than 80% of THMs.

On the other hand, BSF values were reported to increase linearly with increased Br⁻/DOC in Alibeykoy and Californian natural waters (Ates et al., 2007b; Chow et al., 2007). BSF values in this study showed a certain correlation with Br⁻/DOC. For HAAs, the BSF value increased to approximately 10% when the Br⁻/DOC increased from < 10 to 50 µg/mg. However, the trend of BSF in THMFP was not clear. Generally, the BSF value was below 20% over a wide range of Br⁻/DOC with the exception of R7.

Although Br-DBP was not the primary portion of the total DBPs as described above, these DBPs should not be neglected due to their stronger cytotoxic and genotoxic effects in humans than their chlorinated counterparts (Echigo et al., 2004; Nokes et al., 1999; Woo et al., 2002). Our study showed that the formation of Br-DBP should

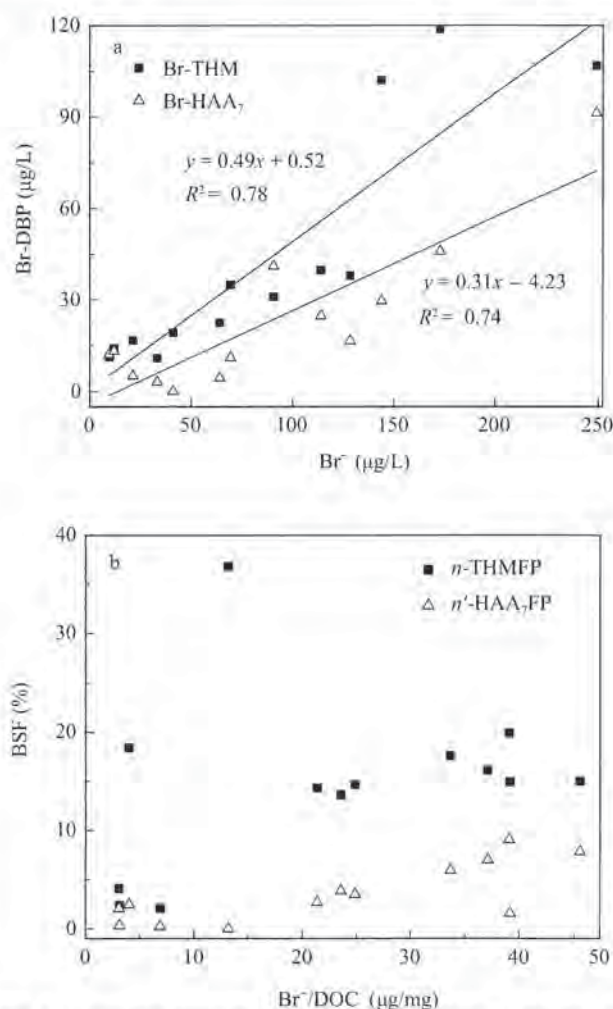


Fig. 2 Correlation between the concentrations of Br-DBP and Br⁻, in addition to bromine substitute factor (BSF) and Br⁻/DOC.

be concerned when the bromide concentration is over 100 µg/L.

The curves in Fig. 2a show higher values for Br-THM than Br-HAA and also for *n*-THMFP than *n'*-HAAFP, which means that bromine formed brominated-THMs more easily than brominated-HAAs under the same conditions. The results of the experiments using other source waters were the same (Sohn et al., 2006). However, because the health risk factor of HAA is higher than THM, Br-HAA should not be neglected in these source waters.

3 Conclusions

THMFP and HAA₇FP in 13 source waters taken from different areas in China were evaluated using the SDS chlorination method, and the following conclusions were drawn. (1) In comparison with THMs, HAAs were the major constituents in most of the source water samples. (2) TCM and BDCM were the major THM species, while TCAA and DCAA were the major HAA species. (3) Br-THM was much higher than Br-HAA, and the formation of Br-DBP should be of concern when the bromide concentration is over 100 µg/L.

Acknowledgements

This work was supported by the High-Tech Research and Development Program (863) of China (No. 2007AA06A414), the National Basic Research Development Program (973) of China (No. 2006CB403306), and the Chinese Academy of Sciences Major Projects of Knowledge Innovation Program (No. KZCX1-YW-06).

References

- APHA, AWWA, WEF, 1995. Standard Methods for the Examination of Water and Wastewater. American Public Health Association, United Book Press, Inc., Baltimore, Maryland.
- Ates N, Kaplan S S, Sahinkaya E, Kitis M, Dilek F B, Yetis U, 2007a. Occurrence of disinfection by-products in low DOC surface waters in Turkey. *Journal of Hazardous Materials*, 142: 526–534.
- Ates N, Yetis U, Kitis M, 2007b. Effects of bromide ion and natural organic matter fractions on the formation and speciation of chlorination by-products. *Journal of Environmental Engineering-Asce*, 133: 947–954.
- Chang S D, Singer P C, 1991. The impact of ozonation on particle stability and the removal of TOC and THM precursors. *Journal of the American Water Works Association, Research & Technology*: 71–79.
- Chow A, Dahlgren R, Harrison J, 2007. Watershed sources of disinfection byproduct precursors in the Sacramento and San Joaquin Rivers, California. *Environmental Science and Technology*, 41: 7645–7652.
- Chow A T, Dahlgren R A, Zhang Q, Wong P K, 2008. Relationships between specific ultraviolet absorbance and trihalomethane precursors of different carbon sources. *Journal of Water Supply Research and Technology-Aqua*, 57: 471–480.
- Echigo S, Itoh S, Natsui T, Araki T, Ando R, 2004. Contribution of brominated organic disinfection by-products to the mutagenicity of drinking water. *Water Science and Technology*, 50: 321–328.
- Gang D D, Segar R L J, Cleverger T E, Banerji S K, 2002. Using chlorine demand to predict TTHM and HAA₉ formation. *Journal of the American Water Works Association*, 94: 76–86.
- Guo Z H, Yang M, Zhang Y, Pei Y S, Zhang J S, Fan J et al., 2006. Preozonation of bromide-bearing source water in South China. *Journal of Environmental Sciences*, 18(2): 209–213.
- Hanson M L, Solomon K R, 2004. Haloacetic acids in the aquatic environment. Part I: macrophyte toxicity. *Environmental Pollution*, 130: 371–383.
- Hargesheimer E E, Watson S B, 1996. Drinking water treatment options for taste and odor control. *Water Research*, 30: 1423–1430.
- Heller G L, Manka J, Limoni R B, Rebhun M, 1993. Formation and distribution of haloacetic acids, THM and tox in chlorination of bromide-rich lake water. *Water Research*, 27: 1323–1331.
- Huang W, Liang C, Li Y, Bao H S, 2004. Effect of NOM characteristics on brominated organics formation by ozonation. *Environment International*, 29: 1049–1055.
- Jung C W, Son H J, 2008. The relationship between disinfection by-products formation and characteristics of natural organic matter in raw water. *Korean Journal of Chemical Engineering*, 25: 714–720.
- Kim J, 2009. Fate of THMs and HAAs in low TOC surface water. *Environmental Research*, 109: 158–165.
- Koch B, Krasner S W, Scilimenti M J, Schimpff W K, 1991. Predicting the formation of DBPs by the simulated distribution system. *Journal of the American Water Works Association*, 62–70.
- Krasner S, McGuire M, Jacangelo J, Patania N, Reagan K, Aieta E, 1989. The occurrence of disinfection by-products in US drinking water. *Journal of the American Water Works Association*, 81: 41–53.
- Nokes C J, Fenton E, Randall C J, 1999. Modelling the formation of brominated trihalomethanes in chlorinated drinking waters. *Water Research*, 33: 3557–3568.
- Oliver B, 1980. Effect of Temperature, pH and Bromide Concentration on the Trihalomethane Reaction of Chlorine with Aquatic Humic Material. Ann Arbor Science Publishers, Ann Arbor, Mich. 141.
- Pourmoghaddas H, Stevens A A, 1995. Relationship between trihalomethanes and haloacetic acids with total organic halogen during chlorination. *Water Research*, 29: 2059–2062.
- Richardson S D, Thruston A D, Rav-Acha C, Groisman L, Popilevsky I, Juraev O et al., 2003. Tribromopyrrole, brominated acids, and other disinfection byproducts produced by disinfection of drinking water rich in bromide. *Environmental Science & Technology*, 37: 3782–3793.
- Sagehashi M, Shiraishi K, Fujita H, Fujii T, Sakoda A, 2005. Ozone decomposition of 2-methylisoborneol (MIB) in adsorption phase on high silica zeolites with preventing bromate formation. *Water Research*, 39: 2926–2934.
- Singer P, Obolensky A, Greiner A, 1995. DBPs in chlorinated North Carolina drinking waters. *Journal of the American Water Works Association*, 87: 83–92.
- Sohn J, Amy G, Yoon Y, 2006. Bromide ion incorporation into brominated disinfection by-products. *Water Air and Soil Pollution*, 174: 265–277.
- Sorlini S, Collivignarelli C, 2005. Trihalomethane formation during chemical oxidation with chlorine, chlorine dioxide and ozone of ten Italian natural waters. *Desalination*, 176: 103–111.
- Symons J, Krasner S, Simms L, Scilimenti M, 1993. Measurement of THM and precursor concentrations revisited: the effect of bromide ion. *Journal of the American Water Works Association*, 85: 51–62.
- Wei Q S, Wang D S, Wei Q, Qiao C G, Shi B Y, Tang H X, 2008. Size and resin fractionations of dissolved organic matter and trihalomethane precursors from four typical source waters in China. *Environmental Monitoring and Assessment*, 141: 347–357.
- Weishaar J L, Aiken G R, Bergamaschi B A, Fram M S, Fujii R, Mopper K, 2003. Evaluation of specific ultraviolet absorbance as an indicator of the chemical composition and reactivity of dissolved organic carbon. *Environmental*

- Science & Technology*, 37: 4702–4708.
- White D M, Garland D S, Narr J, Woolard C R, 2003. Natural organic matter and DBP formation potential in Alaskan water supplies. *Water Research*, 37: 939–947.
- Wong H, Mok K M, Fan X J, 2005. Natural organic matter and formation of trihalomethanes in two water treatment processes. In: 9th International Conference on Environmental Science and Technology. 210, Rhodes, Greece. 44–51.
- Woo Y T, Lai D, McLain J L, Manibusan M K, Dellarco V, 2002. Use of mechanism-based structure-activity relationships analysis in carcinogenic potential ranking for drinking water disinfection by-products. *Environmental Health Perspectives*, 110: 75–87.
- Yan M Q, Wang D S, You S J, Qu J H, Tang H X, 2006. Enhanced coagulation in a typical North-China water treatment plant. *Water Research*, 40: 3621–3627.
- Ye B X, Wang W Y, Yang L S, Wei J R, E X L, 2009. Factors influencing disinfection by-products formation in drinking water of six cities in China. *Journal of Hazardous Materials*, 171: 147–152.
- Zhang H, Qu J H, Liu H J, Zhao X, 2008. Proportion of bromo-DBPs in total DBPs during reclaimed-water chlorination and its related influencing factors. *Science in China Series B-Chemistry*, 51: 1000–1008.

Bay Delta Conservation Plan Effects Analysis Review - Phase 3

January 28th, 2013

David Zippin Ph.D.
Ellen Berryman Ph.D.
Chandra Chilmakuri Ph.D.
Marin Greenwood Ph.D.
Rick Wilder Ph.D.
Jennifer Pierre

Changes Since Last Review

- An informational briefing for the Panel was given on December 18th, 2013
- This briefing provided the Panel with an overview of the changes between the version previously reviewed by the Panel and the current version of the BDCP Effects Analysis and associated technical appendices

Changes Since Last Review

- Revisions made since February 2012 Administrative Draft
 1. Changes to proposed project
 2. Changes to terrestrial effects analysis
 3. Changes to aquatic effects analysis
- Please visit the Delta Science Program website for meeting materials and more information

Charge to the Panel

The Panel is charged with assessing the scientific soundness of Chapter 5: Effects Analysis and the associated technical appendices. The Panel will make recommendations for how these might be improved with respect to achieving their stated goals.

Effects Analysis Presentation Outline

• BDCP Effects Analysis

1. Impacts to greater sandhill cranes and refinements to the conservation strategy currently being explored
2. Effects of Clifton Court Forebay changes
3. Assessment of far-field hydrodynamic changes in the north Delta, and effects on fish
4. Restoration effects
5. Assessment of upstream effects, specifically in the Feather River and Upper Sacramento River
6. Effects downstream of the plan
7. Decision tree analysis
8. Development of the Fish Net Effects Assessment

ANALYSIS OF REVERSE FLOWS AT GEORGIANA SLOUGH

Reverse Flows at Georgiana Slough

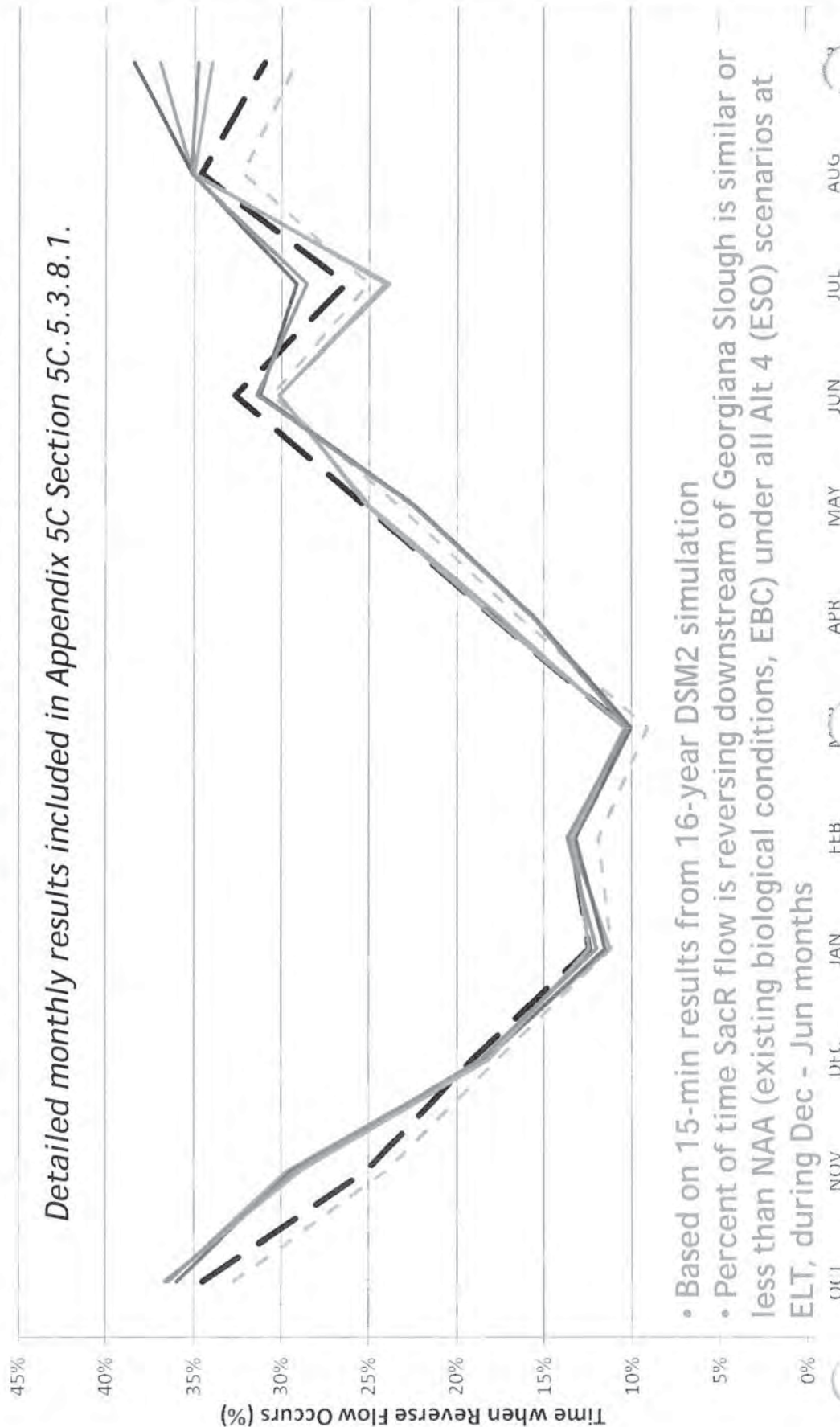
- One of the goals of CM1 north Delta diversion bypass flows criteria is to:
 - avoid increases in the frequency, duration or magnitude of reverse flow in the Sacramento River at Georgiana Slough, during Dec-Jun.

BDCP BAY DELTA CONSERVATION PROGRAM Frequency of Reverse Flows in Sacramento River at Georgiana Slough

Average Percent of Time with Reverse Flow in the Sacramento River d/s of Georgiana SI (ELT)

- - - No Action Alternative — No Action Alternative (ELT) — Alternative 4 LOS (ELT)
 — Alternative 4 SprHOS (ELT) — Alternative 4 ESO (ELT) — Alternative 4 HOS (ELT)

Detailed monthly results included in Appendix 5C Section 5C.5.3.8.1.



Fraction of Total Sacramento River Flow Entering Georgiana Slough

BDCP
BAY DELTA CONSERVATION PLAN

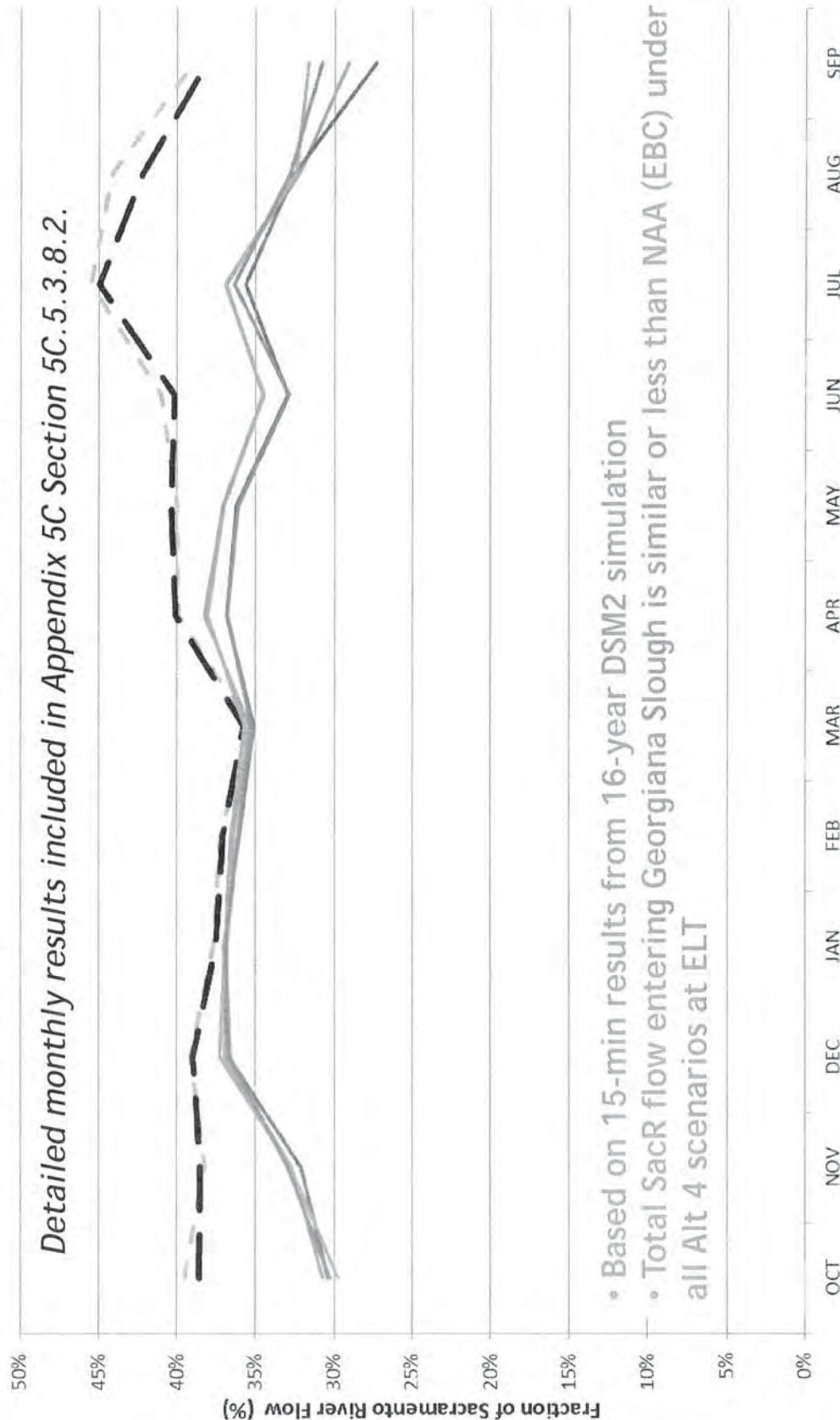
BDCP1563.

52

Georgiana Slough Flow Expressed as a Fraction of Total Flow in the Sacramento River at Georgiana Sl on a Monthly Timestep(ELT)

- - No Action Alternative
 - - No Action Alternative (ELT)
 - - Alternative 4 H1 (ELT)
 - - Alternative 4 H2 (ELT)
 - - Alternative 4 H3 (ELT)
 - - Alternative 4 H4 (ELT)

Detailed monthly results included in Appendix 5C Section 5C.5.3.8.2.



- Based on 15-min results from 16-year DSM2 simulation
- Total SacR flow entering Georgiana Slough is similar or less than NAA (EBC) under all Alt 4 scenarios at ELT

BDCP BAY DELTA CONSERVATION PLAN Fraction of Reversing Sacramento River Flow Entering Georgiana Slough

Fraction of Reverse Flow in the Sacramento River d/s of Georgiana Sl
 Entering Georgiana Slough (ELT)

- - No Action Alternative

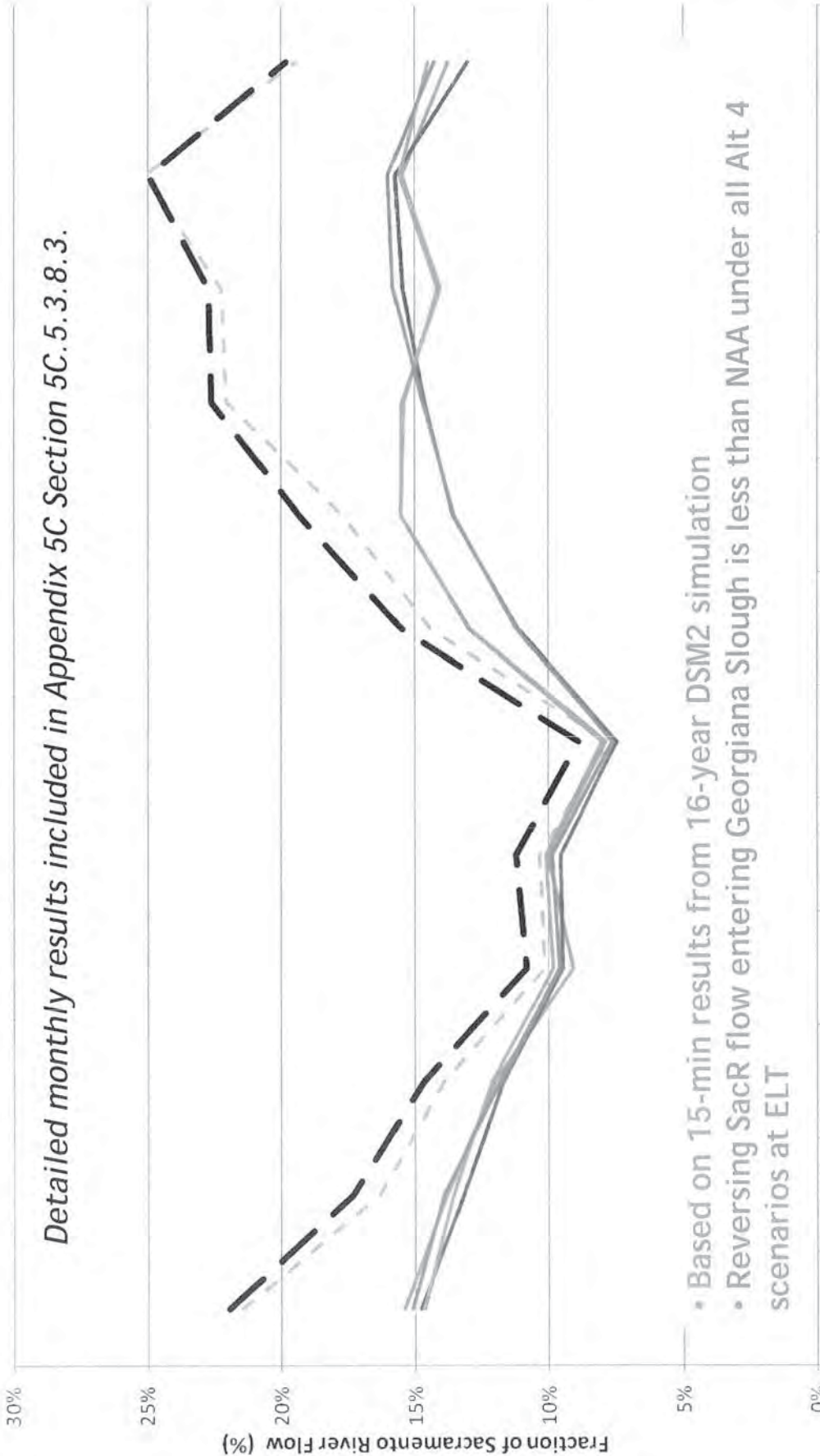
- - Alternative 4 LOS (ELT)

- - Alternative 4 SprHOS (ELT)

- - Alternative 4 ESO (ELT)

- - Alternative 4 HOS (ELT)

Detailed monthly results included in Appendix 5C Section 5C.5.3.8.3.



- Based on 15-min results from 16-year DSM2 simulation
- Reversing SacR flow entering Georgiana Slough is less than NAA under all Alt 4 scenarios at ELT

Frequency of Reverse Flows in Sacramento River at Georgiana Slough

BDCP
BAY DELTA CONSERVATION PLAN

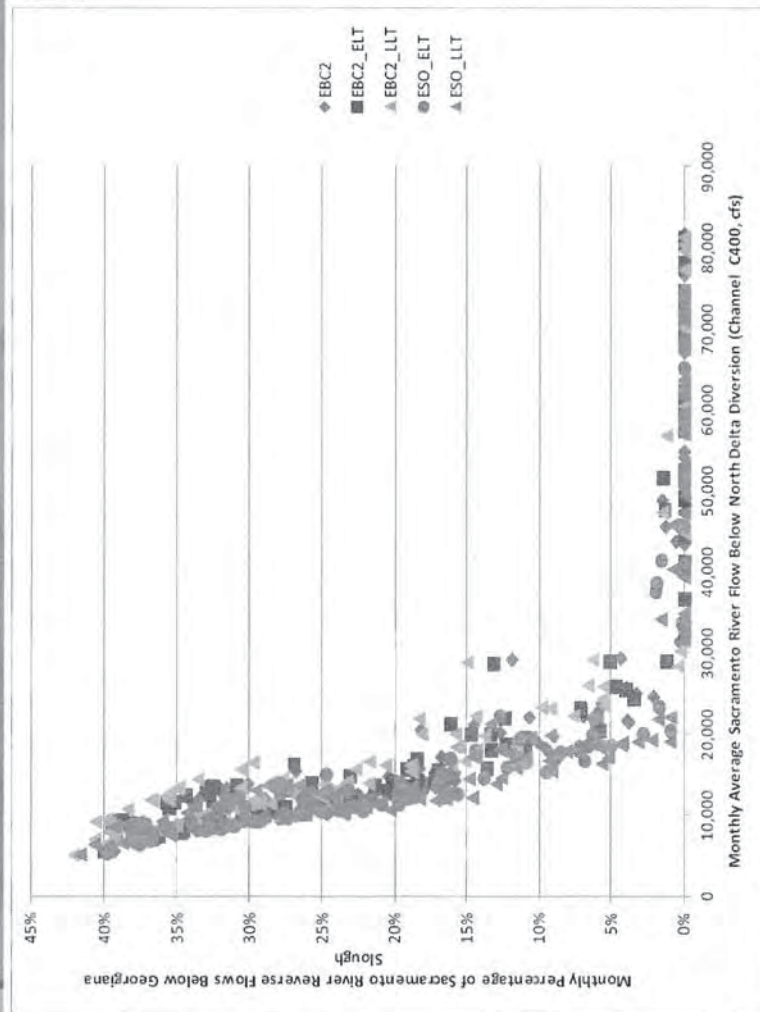


Figure 5C.5.3-142. DSM2-HYDRO-Modeled Percentage of Each Month With Reverse Flows at Sacramento River Below Georgiana Slough (DSM2 Channel 423 at 1000 feet; SAC_37) Versus Mean Monthly Flow in the Sacramento River Below the North Delta Diversions (CALSIM Channel C-400), By Scenario, December–June 1976–1991

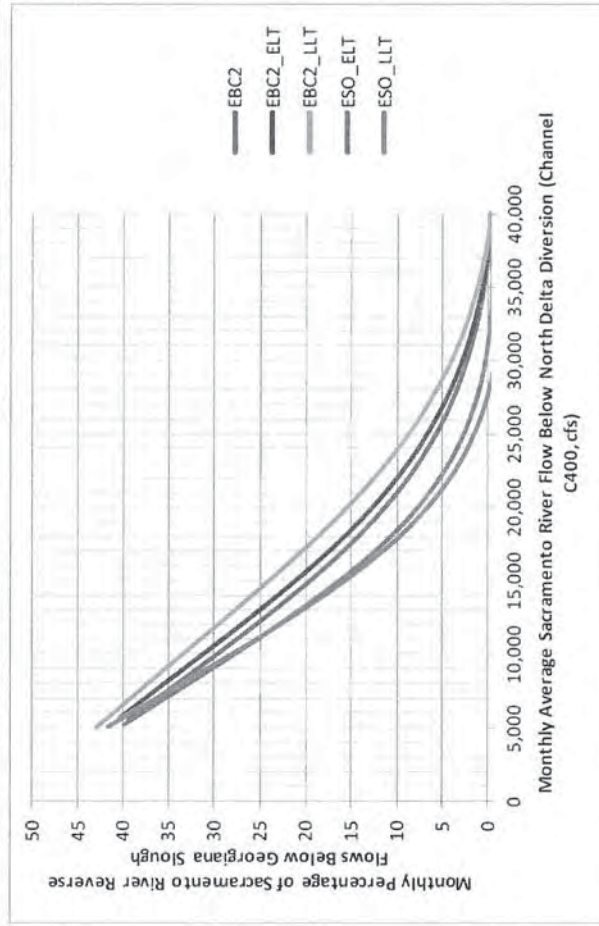


Figure 5C.5.3-143. Generalized Additive Model Splines of DSM2-HYDRO-Modeled Percentage of Each Month With Reverse Flows at Sacramento River Below Georgiana Slough (DSM2 Channel 423 at 1000 feet; SAC_37) Versus Mean Monthly Flow in the Sacramento River Below the North Delta Diversions (CALSIM Channel C-400), By Scenario, December–June 1976–1991

BDCP1563.

Changes in Stage Gradient across Georgiana Slough

BDCP
BAY DELTA CONSERVATION PLAN

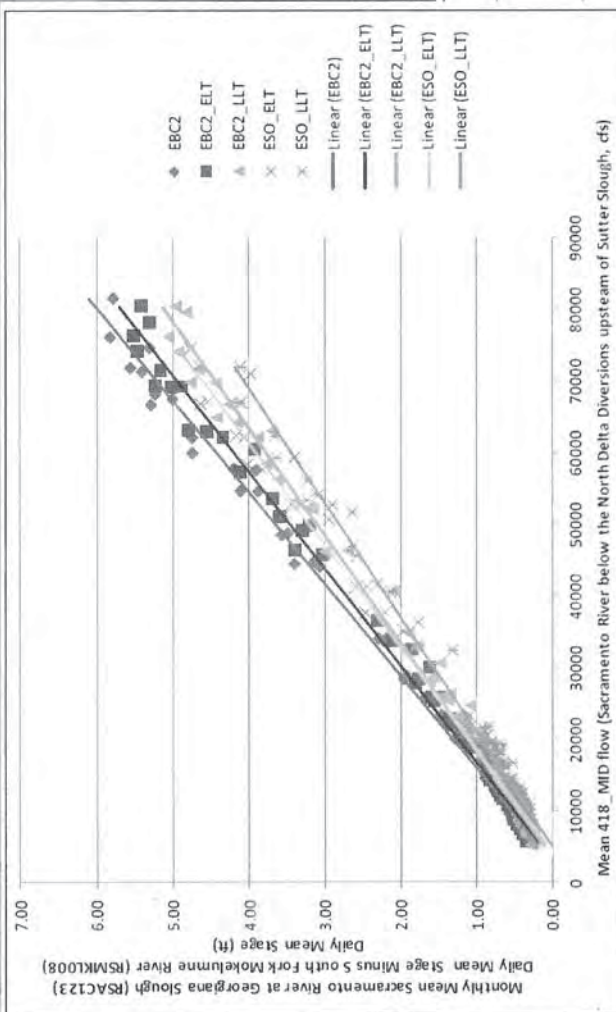


Figure 5C.5.3-144. Stage Gradient (Feet) Between Sacramento River at Georgiana Slough and the South Fork Mokelumne River In Relation to Sacramento River Below North Delta Diversion Flow, Based on Monthly Mean of Daily Data for January–May 1976–1991 from DSM2-HYDRO Modeling



Figure 5C.5.3-145. Stage Gradient (Feet) Between Sacramento River at Georgiana Slough and the South Fork Mokelumne River In Relation to Sacramento River Below North Delta Diversion Flow, Based on Monthly Mean of Daily Data for January–May 1976–1991 from DSM2-HYDRO Modeling

Limited to Flows of 20,000 cfs and Lower

BDCP1563

Changes in Tidal Range in Sacramento River at Georgiana Slough

BDCP
BAY DELTA CONSERVATION PLAN

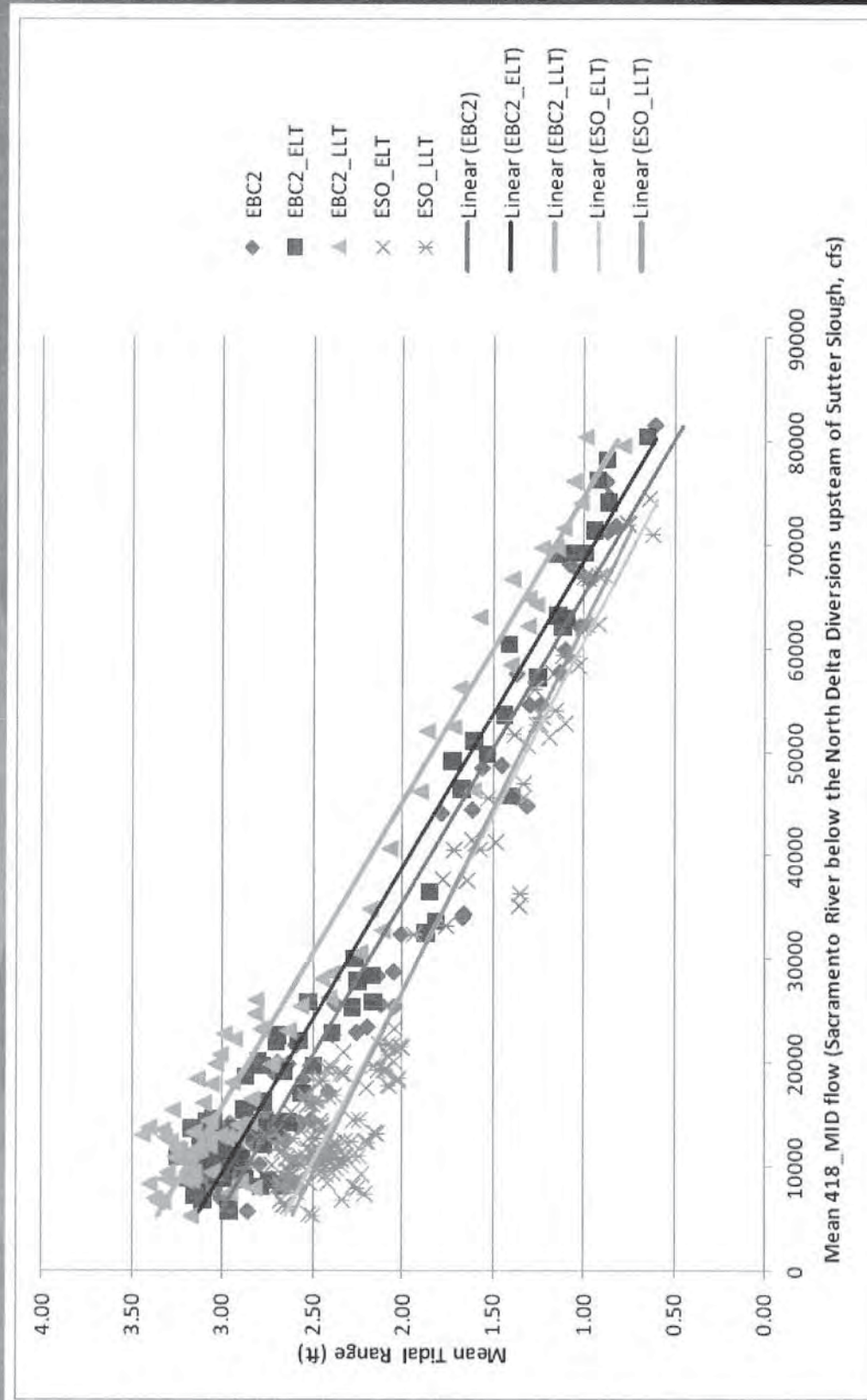


Figure 5C.5.3-141. DSM2-HYDRO-Modeled Mean Monthly Tidal Range (Daily Maximum – Daily Minimum Stage) at Sacramento River at Georgiana Slough (DSM2 Channel RSAC123) Versus Mean Monthly Flow in the Sacramento River Below the North Delta Diversions and Upstream of Sutter Slough (DSM2 Channel 418_MID), By Scenario, January–May 1976–1991

Sensitivity Run Confirms the Effect of Restoration on Reverse Flows

BDCP

BAY DELTA CONSERVATION PLAN

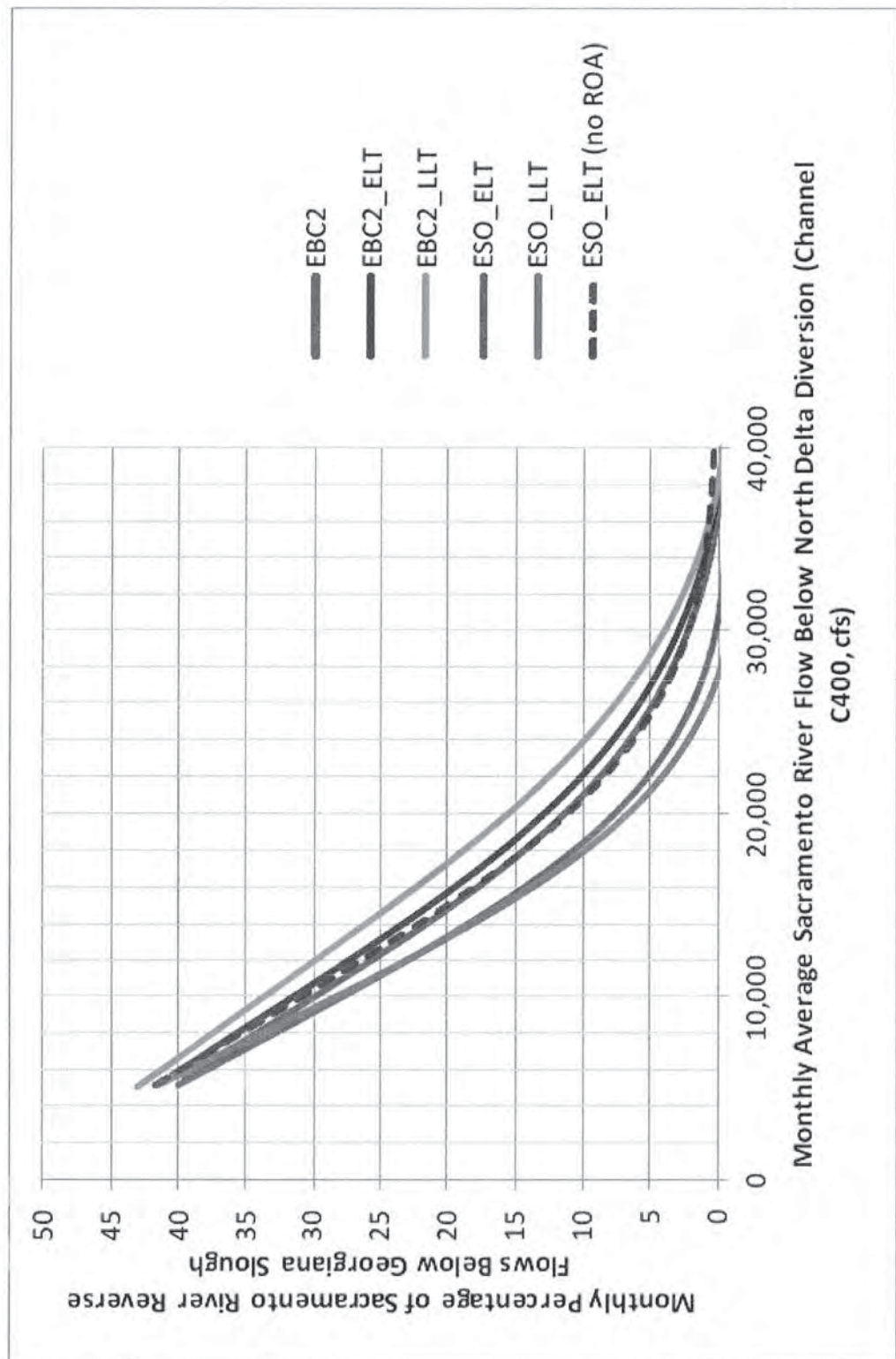


Figure 5C.5.3-147. Generalized Additive Model Splines of DSM2-HYDRO-Modeled Percentage of Each Month With Reverse Flows at Sacramento River Below Georgiana Slough (DSM2 Channel 423 at 1000 feet; SAC_37) Versus Mean Monthly Flow in the Sacramento River Below the North Delta Diversions (CALSIM Channel C-400), By Scenario (Including Illustrative ESO_ELT [No ROA] Scenario), December–

June 1976–1991

Factors Affecting Tidal Conditions near Georgiana Slough under BDCP

BDCP

BAY DELTA CONSERVATION PLAN

- Tidal attenuation in the Sacramento River due to restoration reduces the frequency of reverse flows under BDCP.
- Water level gradient across Georgiana Slough is reduced primarily due to the restoration (tidal attenuation) in Sacramento River, and to a smaller extent due to north Delta diversion.
- Reduced stage gradient across Georgiana Slough results in less Sacramento River flow entering Georgiana Slough under BDCP.

Contra Costa Water District
Comments on the December 13, 2013
Draft Bay Delta Conservation Plan and Accompanying Dra

Exhibits

SED's notes
re: codable
content

1. Alameda County Water District, City of San Diego, Contra Costa Wat Bay Municipal Utility District, San Diego County Water Authority, San Francisco Public Utilities Commission, and Otay Water District, 2013. Letter to U.S. Department of Interior and California Natural Resources Agency regarding A Portfolio-Based BDCP Conceptual Alternative. January 16, 2013.
2. Baxter, R., R. Breuer, L. Brown, M. Chotkowski, F. Feyrer, M. Gingras, B. Herbold, A. Mueller-Solger, M. Nobriga, T. Sommer and K. Souza. (2008) *Pelagic Organism Decline Progress Report: 2007 Synthesis of Results*. (Available at: http://www.science.calwater.ca.gov/pdf/workshops/POD/IEP_POD_2007_synthesis_report_031408.pdf)
3. BDCP, 2008. BDCP Interactive CalLite Screening Evaluations II. Meeting Summary. December 1-2, 2008.
4. CALFED, 2000. *CALFED Bay-Delta Programmatic Record of Decision*. August 28, 2000.
5. CALFED, 2007. *CALFED Water Quality Program Stage 1 Final Assessment*. October 2007.
6. California Department of Fish and Game, 2009. California Endangered Species Act Incidental Take Permit No. 2081-2009-013-03. Contra Costa Water District Maintenance and Operation of the Los Vaqueros Project and Alternative Intake Project. November 9, 2009.
7. California Farm Bureau Federation, 2010. *Comments on Bay Delta Conservation Plan; January 29, 2010 Decisions Regarding Near- and Long-term Operations*. Letter to Under Secretary Karen Scarborough, Natural Resources Agency. January 28, 2010.
8. California Natural Resources Agency, 2013. *Portfolio Approach to Statewide Management and the Bay Delta Conservation Plan* in a Letter to San Diego County Water Authority. September 11, 2013.
9. CCWD, 1988. *Resolution No. 88-45, A Resolution of the Board of Directors of Contra Costa Water District Affirming the Contra Costa Water District's Goals and Objectives for the Los Vaqueros Reservoir Project*. August 1988.
10. CCWD, 2009a. *BDCP Operational Parameters and Effects Analysis, Follow-up to September 10, 2009, Steering Committee Meeting*. Letter to BDCP Steering Committee. September 16, 2009.

11. CCWD, 2009b. *Comments on the Revised Notice of Preparation (February 13, 2009) of the Environmental Impact Report/Environmental Impact Statement (EIR/EIS) for the Bay Delta Conservation Plan (BDCP)*. May 14, 2009.
12. CCWD, 2010. *Historical Fresh Water and Salinity Conditions in the Western Sacramento-San Joaquin Delta and Suisun Bay: A summary of historical reviews, reports, analyses and measurements*. Water Resources Department. Technical Memorandum WR10-001. February 2010.
13. CCWD and DWR, 1967. Agreement. April 21, 1967.
14. CCWD and Reclamation, 2006. *Draft Environmental Impact Report/Environmental Impact Statement for the Contra Costa Water District Alternative Intake Project*, State Clearinghouse # 2005012101, Contra Costa Water District and U.S. Department of the Interior, Bureau of Reclamation, Mid-Pacific Region, May 2006.
15. Chorus, I., I.R. Falconer, H.J. Salas, J. Bartram, 2000. "Health risks caused by freshwater cyanobacteria in recreational waters." *Journal of Toxicology and Environmental Health Part B: Critical Reviews*, 3(4):323-347, doi: 10.1080/109374000436364.
16. DESY, 2011. "Tunnel Construction for the European XFEL. News about the subsidence above the tunnel of 2 July 2011." Accessed July 11, 2014.
http://www.desy.de/news/subsidence/index_eng.html
17. DWR, 2007. *Sources of Salinity in the South Sacramento-San Joaquin Delta*. Memo Report to Dean F. Messer, Chief, Environmental Assessment Branch, from Barry L. Montoya, Staff Environmental Scientist, Department of Water Resources. May 30, 2007.
18. DWR, 2009a. An Overview of the Draft Conservation Strategy for the Bay Delta Conservation Plan. Department of Water Resources. January 12, 2009.
19. DWR, 2009b. *Jones Tract Flood Water Quality Investigations*. Municipal Water Quality Investigations Program, Division of Environmental Services, Department of Water Resources. July 2009.
20. DWR, 2010. *Comments on the Sacramento Regional County Sanitation District's tentative National Pollutant Discharge Elimination System Permit Renewal for the Sacramento Regional Wastewater Treatment Plant*. Letter to Kathy Harder, Central Valley Regional Water Quality Control Board from Gerald E. Johns, Department of Water Resources. October 1, 2010.
21. DWR, 2013a. *CCWD Water Quality Analysis*. Presented to CCWD, February 15, 2013.
22. DWR, 2013b. Modeling files from CalSim II, DSM2, and SRWQM developed as the basis for the BDCP Draft EIR/EIS for the Existing Conditions with Fall X2, No Action Alternative with Fall X2, and Alternatives 1 through 9. Provided by Department of Water Resources to CCWD on an external hard drive on March 28, 2013.

- not available 23. DWR, 2014a. "Clifton Court Forebay Diversions/8500." Accessed June 19, 2014. Available at http://baydeltaoffice.water.ca.gov/sdb/sdip/features/ccf_diversions.cfm.
- not available 24. DWR, 2014b. Monthly reservoir storage at San Luis Reservoir. California Data Exchange Center, Department of Water Resources. Accessed June 11, 2014. http://cdec.water.ca.gov/cgi-progs/selectQuery?station_id=SNL
- not available 25. DWR, 2014c. Monthly reservoir storage at Shasta Dam. California Data Exchange Center, Department of Water Resources. Accessed June 11, 2014. http://cdec.water.ca.gov/cgi-progs/selectQuery?station_id=SHA
- not available 26. DWR, 2014d. "Water Use Efficiency." Accessed June 24, 2014. <http://www.water.ca.gov/wateruseefficiency/>
- not available 27. Federal Register, 2009. *Drinking Water Contaminant Candidate List 3-Final*. Volume 74, Number 194, October 8, 2009.
- not available 28. Fischer, H. B., E.J. List, R. C. Y. Koh, J. Imberger, and N.H. Brooks, N. H, 1979. *Mixing in inland and coastal waters*. Academic Press, San Diego.
- not available 29. Ingebritsen, S.E. and M.E. Ikehara, 1999. "Sacramento-San Joaquin Delta: The sinking heart of the state." In *Land Subsidence in the United States*. U.S. Geological Survey Circular 1182:83-94.
- not available 30. Kalbitz, K. and S. Geyer, 2002. "Different effects of peat degradation on dissolved organic carbon and nitrogen." *Organic Geochemistry*, 33:319-326.
- not available 31. Kegel, F.R., 1979. "Farming Organic Soils of the Delta." *California Agriculture* 33:11. November-December 1979. doi:10.3733/ca.v033n11p6.
- not available 32. Korth, W., J. Ellis, K. Bowmer, 1992. "The Stability of Geosmin and MIB and their deuterated analogues in Surface Waters and Organic Solvents," *Water Science and Technology*, 25, no. 2, 115-122.
- not available 33. Lee, W., P. Westerhoff, J.P. Croue, 2007. "Dissolved Organic Nitrogen as a precursor for chloroform, Dichloroacetonitrile, N-Nitrosodimethylamine, and Trichloronitromethane." *Environmental Science and Technology* 41, no. 15, 5485-5490. doi: 10.1021/es070411g.
- not available 34. Lehman, P. W., G. Boyer, M. Satchwell, S. Waller, 2008. "The influence of environmental conditions on the seasonal variation of Microcystis cell density and microcystins concentration in San Francisco Estuary." *Hydrobiologia*, 600(1):187-204. doi: 10.1007/s10750-007-9231-x.
- not available 35. Lehman, P.W., K. Marr, G.L. Boyer, S. Acuna, S.J. The, 2013. "Long-term trends and causal factors associated with *Microcystis* abundance and toxicity in San Francisco Estuary and implications for climate change impacts." *Hydrobiologia*, 718(1):141-158. doi: 10.1007/s10750-013-1612-8.

- not
credible
36. Linville, R. G., Luoma, S. N., Cutter, L., Cutter, G. A., 2002. "Increased selenium threat as a result of invasion of the exotic bivalve *Potamocorbula amurensis* into the San Francisco Bay-Delta." *Aquatic Toxicology*, 57(1), 51-64. doi: 10.1016/S0166-445X(01)00265-X.
- not
credible
37. MacWilliams, M., A. Bever, N. Hume, E. Loboschefskey, S. Siegel, 2014. "Evaluation of the Effects of Prospect Island Restoration on Sediment Transport and Turbidity." Presented at the annual meeting of the California Water Environmental Modeling Forum, Sacramento, California. February 26, 2014.
- credible
38. MBK Engineers and D.B Steiner, 2014. Report on Review of Bay Delta Conservation Program Modeling.
- not
credible
39. Metropolitan Water District of Southern California, 2014a. Conservation Program Website "BeWaterWise.com". Accessed July 16, 2014. <http://www.bewaterwise.com/>
- not
credible
40. Metropolitan Water District of Southern California, 2014b. Southern California Water World Forum. Accessed July 16, 2014. http://www.mwdh2o.com/mwdh2o/pages/education/world_water_01.html
- not
credible
41. Mitch, W., A.C. Gercke, D.L. Sedlak, 2003. "A N-Nitrosodimethylamine (NDMA) precursor analysis for chlorination of water and wastewater." *Water Research*, (37):3733-3741. doi: 10.1016/S0043-1354(03)00289-6
- not
credible
42. Monsen, N. E., J.E. Cloern, L. V. Lucas, and S. G. Monismith, S. G., 2002. "A comment on the use of flushing time, residence time, and age as transport time scales." *Limnology and Oceanography*. 47(5), 1545-1553.
- not
credible
43. NMFS, 1993. National Oceanic and Atmospheric Administration, National Marine Fisheries Service (NMFS) Biological Opinion on Winter-run Chinook Salmon for the Los Vaqueros Project. March 18, 1993.
- not
credible
44. NMFS, 2009. Biological and Conference Opinion on the Long Term Central Valley Project (CVP) and State Water Project (SWP) Operations Criteria and Plan (OCAP) Operations. No. 2008/09022. National Marine Fisheries Service, Southwest Region. June 4, 2009.
- not
credible
45. NRDC, 2013a. "Benefits of a Diversified Portfolio Approach to the Bay-Delta and Water Supply."
- not
credible
46. NRDC, 2013b. "Growing Support for Analysis of Bay-Delta Conceptual Alternative." Natural Resources Defense Council Staff Blog by Doug Obegi. Accessed June, 24, 2014. http://switchboard.nrdc.org/blogs/dobegi/growing_support_for_analysis_o.html
- not
credible
47. Office of Environmental Health Hazard Assessment, 2009. *Microcystis: Toxic Blue-Green Algae*. February 2009.

48. Paerl, H.W., 1996. "A comparison of cyanobacterial bloom dynamics in freshwater, estuarine and marine environments." *Phycologia*, 35(6S):25-35. doi: 10.2216/i0031-8884-35-6S-25.1.
49. Parker, A., C. Simenstad, T.L. George, N. Monsen, T. Parker, G. Ruggerone, J. Skalski, 2014. "Delta Science Program Independent Review Panel Report. BDCP Effects Analysis Review, Phase 3." March 2014.
50. Persson, P. E., 1980. "Sensory properties and analysis of two muddy odour compounds, geosmin and 2-methylisoborneol, in water and fish." *Water Research*, 14(8), 1113-1118.
51. Presser, T. S. and S.N. Luoma, 2013. "Ecosystem-scale Selenium Model for the San Francisco Bay-Delta Regional Ecosystem Restoration Implementation Plan." *San Francisco Estuary and Watershed Science*. 11(1).
52. Reclamation, 2013a. "Reclamation's List of Key BDCP Adm. Draft EIR/EIS Issues. July 5, 2013. Clarification Added: July 16, 2013" in *Federal Agency Comments Received on the Bay Delta Conservation Plan (BDCP) Second Administrative Draft Environmental Impact Report/Environmental Impact Statement (EIR/EIS)*. July 18, 2013.
53. Reclamation, 2013b. *San Luis Reservoir Expansion Draft Appraisal Report*. U.S. Department of the Interior, Bureau of Reclamation, Mid-Pacific Region – Planning Division. December 2013.
54. Reclamation, 2014. U.S. Department of the Interior, Bureau of Reclamation, Mid-Pacific Region. Central Valley Operation. Water Operations Analysis. "50% Forecast." May 23, 2014. Accessed June 11, 2014. <http://www.usbr.gov/mp/cvo/data/May50.pdf>
55. Reclamation and DWR, 1986. "Agreement between the United States of America and the Department of Water Resources of the State of California for Coordinated Operation of the Central Valley Project and the State Water Project." November 24, 1986
56. Reclamation and DWR, 2013. *North-of-the-Delta Offstream Storage Investigation 2013 Progress Report*. December 2013.
57. Reclamation and SCVWD, circa 2008. *San Luis Low Point Improvement Project*. U.S. Department of the Interior, Bureau of Reclamation, Mid-Pacific Region and Santa Clara Valley Water District.
58. Reclamation, USFWS, and CDFG, 2011. *Final Environmental Impact Statement/ Environmental Impact Report for the Suisun Marsh Habitat Management, Preservation, and Restoration Plan*. State Clearinghouse 2003112039. November 2011.
59. Reddy, K.R., 2005. *Review of Delta Wetlands Water Quality: Release and Generation of Dissolved Organic Carbon from Flooded Peatlands (Final Report)*. March 2005.
60. RMA, 2010. "Potential Impacts of Large-Scale Delta Levee Failure on BDCP Restoration and Intake Investments. RMA Model Analysis." Presented to BDCP Steering

Committee on July 29, 2010. Available at
<http://baydeltaconservationplan.com/Library/ArchivedDocuments/SteeringCommittee/SteeringCommitteeAgendasAndHandouts.aspx>

61. RMA, 2013. "Recent Projects Modeling Local and Regional Impacts of Tidal Marsh Restoration." Presented to the Delta Independent Science Board on January 17, 2013.
62. Semitropic Water Storage District, 2011. *Delta Wetlands Project Place of Use Final Environmental Impact Report*. August 2011.
63. Sereno, D.M. and M.T. Stacey, 2004. "Hydrodynamics in Franks Tract – Observations and Modeling Influence of Submerged Aquatic Vegetation (SAV)." Presented at the CALFED Bay-Delta Science Conference. October 2004.
64. Sereno, D., M.T. Stacey, S. Baek, J.R. Burau, J.I. Cuetara, C.A. Ruhl, R.L. Dinehart, and J.E. George, 2003. "Using Hydrodynamics to Examine Differences in Flooded Island Environments. Lessons Learned, Questions Raised." Presented at CALFED Ecosystem Restoration Program Seminar. April 2003.
65. State Water Project Contractors Authority and DWR, 2012. *California State Water Project SWP Watershed Sanitary Survey, 2011 Update*. June 2012
66. SWRCB, 1968. "Statement of policy with respect to maintaining high quality of waters in California." *State Water Resources Control Board Resolution No. 68-16*.
67. SWRCB, 2004. "In the Matter of the Approval of the Water Quality Response Plan Under SWRCB Decision 1641." *State Water Resources Control Board Order WRO 2004-0043-EXEC*.
68. SWRCB, 2010. Permit for Diversion and Use of Water. Amended Permit 20749. Application 20245 of Contra Costa Water District. July 8, 2010.
69. SWRCB, 2013. *Comments on the Second Administrative Draft Environmental Impact Report/Environmental Impact Statement for the Bay Delta Conservation Plan*. Letter to Mr. Russell Stein, California Department of Water Resources. July 5, 2013.
70. The Bay Institute, NRDC, Planning and Conservation League, Environmental Entrepreneurs, Defenders of Wildlife, Contra Costa Council, 2013c. "New Plan Offers an Effective, Affordable Package of California Water Supply and Bay-Delta Fisheries Solutions." Press Release. January 16, 2013.
71. Trojan Technologies, 2010. *Trojan UV Factsheet: Taste and Odor – Environmental Contaminant Treatment*, London, Ontario, Canada.
72. USEPA, 1998. *Empirically Based Models for Predicting Chlorination and Ozonation By-Products: Trihalomethanes, Haloacetic Acids, Chloral Hydrate, and Bromate*. EPA 815-R-98-005. August 1998.

73. USEPA, 2011. "Water Quality Challenges in the San Francisco Bay/Sacramento-San Joaquin Delta Estuary." *Unabridged Advance Notice of Proposed Rulemaking*. February 2011.
74. USEPA, 2012. "Water Quality Challenges in the San Francisco Bay/Sacramento-San Joaquin Delta Estuary." *EPA's Action Plan*. August, 2012.
75. USEPA, 2013a. "Basic information about disinfection byproducts in drinking water: Total Trihalomethanes, Haloacetic Acids, Bromate, and Chlorite." Website last updated December 31, 2013.
<http://water.epa.gov/drink/contaminants/basicinformation/disinfectionbyproducts.cfm>
76. USEPA, 2013b. "Bromate (CASRN 15541-45-4)." *United States Environmental Protection Agency. (2013b) Integrated Risk Information System*. January 24, 2013. Available at <http://www.epa.gov/iris/subst/1002.htm>
77. USEPA, 2013c. "N-Nitrosodimethylamine (CASRN 62-75-9)". *United States Environmental Protection Agency. Integrated Risk Information System*. January 24, 2013. Available at <http://www.epa.gov/iris/subst/0045.htm>
78. USFWS, 1993. *Formal Endangered Species Consultation on Effects of the Proposed Los Vaqueros Reservoir Project on San Joaquin kit fox and Bald eagle, Contra Costa County, California*. U.S. Department of the Interior, Fish and Wildlife Service, Sacramento, California. File No 1-1-92-F-48, 1993.
79. USFWS, 2000. *Formal ESA Consultation for CCWD's Construction of a Multipurpose Pipeline and Future Water Supply Implementation Program, No. 1-1-99-F-93*. U.S. Fish and Wildlife Service. April 27, 2000.
80. USFWS, 2005. *Reinitiation and Amendment of Formal Consultation and Conference on CCWD's Future Water Supply Implementation Program (Service file no. 1-1-99-F-0093) for the Renewal of the Central Valley Project Long Term Water Service Contract, Contra Costa County, California*. U.S. Fish and Wildlife Service. March 11, 2005.
81. USFWS, 2008. *Formal ESA Consultation for the Proposed Coordinated Operations of the CVP and SWP, No. 81420-2008-F-1481-5*, U.S. Fish and Wildlife Service, December 15, 2008.
82. USFWS, 2013a. *U.S. Fish and Wildlife Service Staff BDCP Progress Assessment*. April 3, 2013.
83. USFWS, 2013b. "U.S. Fish and Wildlife Service Staff BDCP ADEIS Review" in *Federal Agency Comments Received on the Bay Delta Conservation Plan (BDCP) Second Administrative Draft Environmental Impact Report/Environmental Impact Statement (EIR/EIS)*. July 18, 2013.

- Not
codable
84. Westlands Water District, 2013. "Bay Delta Conservation Plan & Delta Habitat Conservation & Conveyance Program." Presentation at Board Workshop. November 20, 2013.
- Not
codable
85. Zhang, J., J. Yu, W. An, J. Liu, Y. Wang, Y. Chen, J. Tai, M. Yang, 2011. "Characterization of Disinfection Byproduct Formation Potential in 13 Source Water in China." *Journal of Environmental Sciences*, 23(2):183-188. doi: 10.1016/S1001-0742(10)60440-8
- Not
codable
86. Zippin, D., E. Berryman, C. Chilmakuri, M. Greenwood, R. Wilder, J. Pierre. "Bay Delta Conservation Plan Effects Analysis Review – Phase 3." Presented to the Delta Science Program Independent Science Review Panel. January 28, 2014.

