

RECLAMATION

Managing Water in the West

Initial Alternatives Information Report for the North/Central Delta Improvement Study (Delta Cross Channel, Franks Tract, and Through- Delta Facility Evaluation)



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.

RECLAMATION

Managing Water in the West

Initial Alternatives Information Report for the North/Central Delta Improvement Study (Delta Cross Channel, Franks Tract, and Through- Delta Facility Evaluation)



Executive Summary

The U.S. Department of the Interior (Interior) Bureau of Reclamation (Reclamation) and the California Department of Water Resources (DWR) are evaluating the feasibility of using conveyance and operations actions in the north and central region of the Sacramento–San Joaquin River Delta (Delta) to improve water quality and fish conditions. Specifically, Reclamation is evaluating the feasibility of these actions in the North/Central Delta Improvement Study (NoCDIS or Study).

The Initial Alternatives Information Report (IAIR) identifies, discusses, and screens measures to address the problems and opportunities. These measures are used to develop initial alternatives. Initial alternatives from the IAIR will be incorporated into and refined in the subsequent Plan Formulation Report (PFR). Subject to continued appropriations and a determination of federal interest, the Study should culminate in an Environmental Impact Statement/Environmental Impact Report (EIS/EIR) and a Feasibility Report. Reclamation is the federal lead agency for National Environmental Policy Act (NEPA) compliance, and DWR is the state lead agency for California Environmental Quality Act (CEQA) compliance.

Purpose and Scope of Report

The purpose of this IAIR is to identify the initial alternatives that will be carried forward for additional analysis in the plan formulation and feasibility phases of the Study. Reclamation has completed technical studies that provide the information required for the analyses performed in this IAIR. More detailed alternatives will be developed from these initial alternatives during the next phases of the Study.

The IAIR will accomplish the following:

- Describe present and future baseline conditions
- Identify problems and opportunities
- Set forth purpose and need and planning objectives
- Formulate a range of measures for the project
- Combine those measures into alternative plans

Complete alternatives that address the planning objectives are discussed in the IAIR, as well as the related potential environmental impacts and results of initial screening. A comparison of alternatives is provided to refine the alternatives that will be considered further in subsequent steps of the planning process. Based on this evaluation, the IAIR identifies a potential federal interest in the NoCDIS project.

Study Authorization

The CALFED Bay-Delta Authorization Act of 2004 (Public Law 108-361, Section 103) authorizes the Secretary of the Interior to carry out feasibility studies (via Reclamation), as follows:

- Section 103(d)(2) Conveyance
(B) North Delta Actions:
 - “(i) evaluation and implementation of improved operational procedures for the Delta Cross Channel to address fishery and water quality concerns.
 - (ii) evaluation of a screened through-Delta facility on the Sacramento River.”
- Section 103(f)(1) Conveyance
(C) Franks Tract
 - “Funds may be expended for feasibility studies and actions at Franks Tract to improve water quality in the Delta.”

Reclamation chose to study these actions to determine if the actions could, alone or in combination, meet the study objectives.

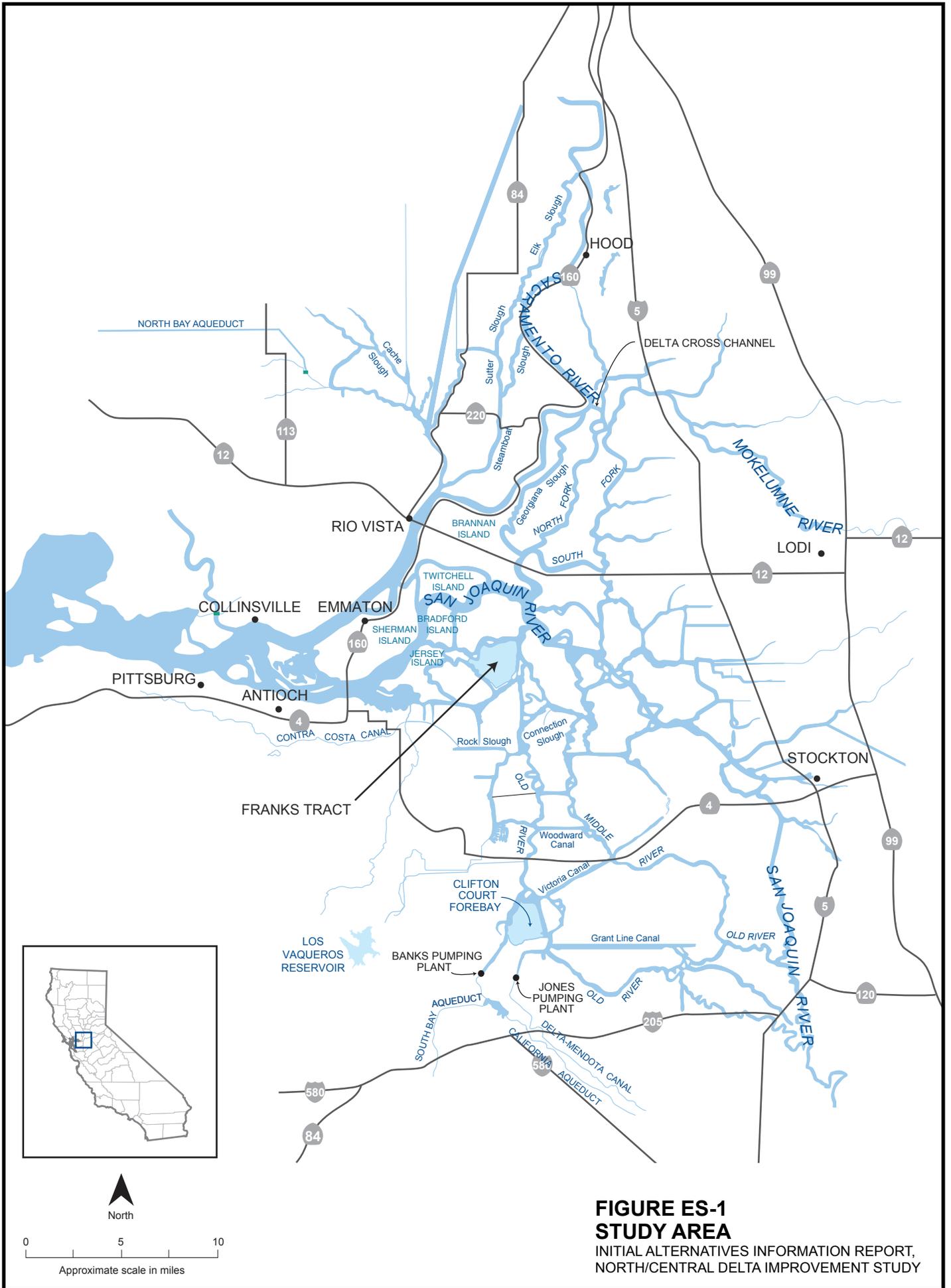
Study Area

The Study area, shown in Figure ES-1, involves sections of the north, central, and south Delta, including the waterways around Franks Tract, the Sacramento River, the South Fork of the Mokelumne River, the Delta Cross Channel, and the lower San Joaquin River. Much of the land within the Study area is subject to agricultural activities, while the waterways provide recreational opportunities; valuable wildlife habitat; and serve as major residential, municipal, and agricultural water supplies to much of the state.

Water Resources Problems, Needs, and Opportunities

This IAIR has been developed to address two specific problems in the Study area. The first problem to be addressed is quality of water in the south Delta being pumped at the Jones Pumping Plant and the Banks Pumping Plant. The second problem is fisheries conditions throughout the Delta.

Water quality in the south Delta has been affected by salinity from tidal intrusion and farming runoff, pesticides, and selenium primarily from agricultural drainage, and mercury from historic mining operations in the Delta watershed. Currently, the interior Delta water quality standards, established by D-1641, are difficult to achieve due to the complex hydrodynamics of the Delta and present Central Valley Project /State Water Project (CVP/SWP) operations. Current water quality problems in the Delta may be further exacerbated due to future demands on a fixed water supply and other factors.



This page intentionally left blank.

Additionally, recent, unprecedented declines of pelagic and anadromous fish have led to listings of several species under the state and federal Endangered Species Acts, court-ordered shutdowns of water diversions, and millions of dollars spent on associated legal proceedings.

Reclamation, through NoCDIS, is investigating the opportunities to both reduce salinity levels and improve fishery conditions throughout the Delta. Since the Flooded Islands Pre-Feasibility Study in 2005, DWR's Bay-Delta Office has continued technical studies, conceptual designs, cost estimates, and water quality modeling in support of facilities at Franks Tract for water quality and fisheries benefits. These pre-feasibility-level studies have resulted in five alternatives. In addition to the Franks Tract alternatives, Reclamation's NoCDIS Plan of Study (August 2007) included other alternatives in the north and central Delta with similar potential to meet the planning objectives.

For the IAIR, alternatives have been identified, evaluated, and screened to determine which has the highest potential benefit to both water quality and fisheries. These opportunities include facilities in the north and central Delta initiated by CALFED or DWR, as well as water management opportunities to meet NoCDIS planning objectives.

Objectives and Resource Management Measures

The objectives of the NoCDIS are to:

1. Improve water quality at the south Delta export facilities while remaining consistent with long-term Delta planning efforts.
2. Improve fisheries conditions throughout the Delta while remaining consistent with long-term Delta planning efforts.

Resource Management Measures were identified to meet each of the two objectives of the project. Measures were developed in the IAIR phase by collecting information on past projects and studies based on some studies already completed by DWR. Some measures were eliminated because they were deemed infeasible or did not best meet the Study's objectives. The measures retained for further consideration were combined into a set of initial alternatives. The challenge faced in developing the alternatives was to balance the need to deliver freshwater with maintaining and improving fish habitat.

Improved water quality at the south Delta export facilities could be achieved by reducing or mitigating the salinity intrusion into the central Delta from the west (from the Pacific Ocean). Several measures were identified as having the potential to meet the first objective:

- 1.1 Increase transfer of Sacramento River flows to the central Delta.
- 1.2 Increase Mokelumne River flows delivered to the central and south Delta.

- 1.3 Reduce tidal and seasonal mixing from the western Delta into Franks Tract.
- 1.4 Increase the net outflow in the lower San Joaquin River near Jersey Point.
- 1.5 Isolate a “fresh water corridor” minimizing mixing with western Delta waters.
- 1.6 Create a longer path for higher salinity water to reach export facilities by creating physical flow barriers.

Several measures were identified as having the potential to meet the second objective, to protect sensitive fish species conditions in the Delta:

- 2.1 Physically prevent sensitive species from entering the central and south Delta from the north and west Delta when the export facilities are operating.
- 2.2 Alter flow operations to encourage fish to remain in the Sacramento River system where mortality rates have been shown to be lower than in the central Delta and Mokelumne River systems.
- 2.3 Physically prevent anadromous species from entering the central Delta, keeping them in the Sacramento River system rather than the Mokelumne River system when outmigrating from the north.
- 2.4 Alter flow operations to negate reverse flows in the central and south Delta, encouraging fish to remain in the north Delta or outmigrate to sea.
- 2.5 Install physical barriers to negate reverse flows in the central and south Delta, preventing fish from entering the area of the export facilities from the north and east.
- 2.6 Install fish screening devices at major diversions.

Of the measures considered, all were retained for further consideration. Measures 1.1, 1.2, and 1.4, developed to address Objective 1, may also have a secondary benefit of improving fisheries.

Development of Initial Alternatives

The Resource Management Measures were expanded and combined into a set of initial alternatives. The alternatives were modeled using CALSIM, DSM2, and a Particle Tracking Model; results were evaluated to assess each alternative’s ability to meet Study objectives. Preliminary cost estimates were collected from other studies, and screening criteria were used to identify which alternatives should be carried forward.

The initial alternatives are organized into Franks Tract Alternatives, Through-Delta Alternatives, and Delta Cross Channel Alternatives to meet CALFED Bay-Delta Authorization Act requirements. Additional management

alternatives that were identified are included in this Study. Figure ES-2 provides a NoCDIS vicinity map. The initial alternatives considered include the following:

- Franks Tract Alternatives
 - Alternative A: Operable Gates on West False River
 - Alternative B1: North Levee and Two Operable Gates
 - Alternative B2: East Levee and Two Operable Gates
 - Alternative C: Gates on Holland Cut and Old River (Cox Alternative)
 - Alternative D: Operable Gates on Three Mile Slough
- Through-Delta Alternatives
 - Alternative E1: Through-Delta Facility (original CALFED facility and alignment)
 - Alternative E2: Through-Delta Facility (alternative concept)
- Delta Cross Channel Alternatives
 - Alternative F1: Delta Cross Channel Modifications and Re-operation
 - Alternative F2: Delta Cross Channel Re-operation Only
- Management Alternatives
 - Alternative G: Mokelumne River Water Exchange
 - Alternative H: Outflow Management/Sacramento River Flow Augmentation

Evaluation and Comparison of Alternatives

Out of the 11 NoCDIS alternatives, four were eliminated based on evaluations conducted by previous studies. The remaining seven NoCDIS alternatives were compared to determine relative influences on hydrodynamics, water quality, and fisheries compared to a baseline simulation. These alternatives were analyzed primarily using the DWR DSM2 model and Particle Tracking Model (PTM). DSM2 predicts the distribution of salinity throughout the model domain as it varies with time. The PTM model was used to gauge influences on larval and juvenile life stage fisheries. Cost estimates were collected from previous studies completed on several of the alternatives compiled by this report. When available, these estimates are provided as a basis for comparison with other alternatives and should be considered order-of-magnitude level.

DSM2 model results indicate that, on average, a TDF (Alternative E1) provides the largest decrease in salinity in the south Delta. The DCC Modifications and Re-operation Alternative (Alternative F1) performs second best in reducing salinity at the export facilities. Operable Gates on Three Mile Slough (Alternative D) outperforms Operable Gates on West False River (Alternative A) which, in turn, outperforms the Outflow Management/Sacramento River Flow Augmentation Alternative (Alternative G), DCC Re-operation Only (Alternative F2), and the Mokelumne River Water Exchange Alternative (Alternative H), listed in decreasing order of performance.

Based on the analyses of the PTM results, as predictive of the biological effects to fisheries, the TDF provides the most significant benefit to fish. This result is consistent with previous studies. The two Franks Tract Alternatives—Operable Gates on Three Mile Slough and Operable Gates on West False River—may provide small benefits to fisheries in the central Delta when the gates are operated primarily for water quality purposes. The DCC Modifications and Re-operation Alternative provide relatively little benefit to fisheries. This conclusion is particularly applicable to Chinook salmon and steelhead, which are more likely to move into the central Delta, thereby increasing their residence time and exposure to poor water quality and predation. However, the additional water in the central Delta with the DCC Alternatives may be beneficial for Delta and longfin smelts and other central Delta fish by reducing entrainment at the export facilities. The two management alternatives—Outflow Management/Sacramento River Flow Augmentation and Mokelumne River Flow Exchange—principally alter flows from April to June and August to September. Because the species of concern are generally not present during these months, these two alternatives do not result in an overall benefit to fisheries.

The fisheries analysis conclusions are highly dependent on many assumptions, reflect the uncertainties inherent in the current state of knowledge, and should be interpreted cautiously. The use of the PTM analyses only provides an indication of possible benefit to fish compared to the baseline condition. Factors including fish population abundances, local environmental conditions, year-to-year variability in spatial and temporal distributions, predator and food abundance, and variability in hydrodynamics would all likely affect fisheries as part of any of the alternatives. It must also be noted that the alternatives evaluated were primarily operated to achieve the water quality objective, but were not optimized to achieve the most favorable conditions for fish; however, this optimization could be performed in future planning studies.

A summary of the alternatives comparison is presented in Table ES-1. The summary includes the comparison of alternatives based on four specific criteria: completeness, effectiveness, efficiency, and acceptability. The federal Water Resources Council's Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (WRC, 1983) specify these four criteria for consideration in screening potential alternatives; therefore, the feasibility of an alternative will be assessed by its ability to accomplish the following:

- The completeness criterion addresses whether the alternative would account for all investments or other actions necessary to realize the planned effects. For the NoCDIS, completeness is considered with respect to the coequal objectives of improving water quality in the south Delta and improving fisheries conditions throughout the Delta.
- The effectiveness criterion addresses how well an alternative would alleviate problems and achieve opportunities. This criterion considers how well the alternative would achieve the coequal planning objectives of water quality and

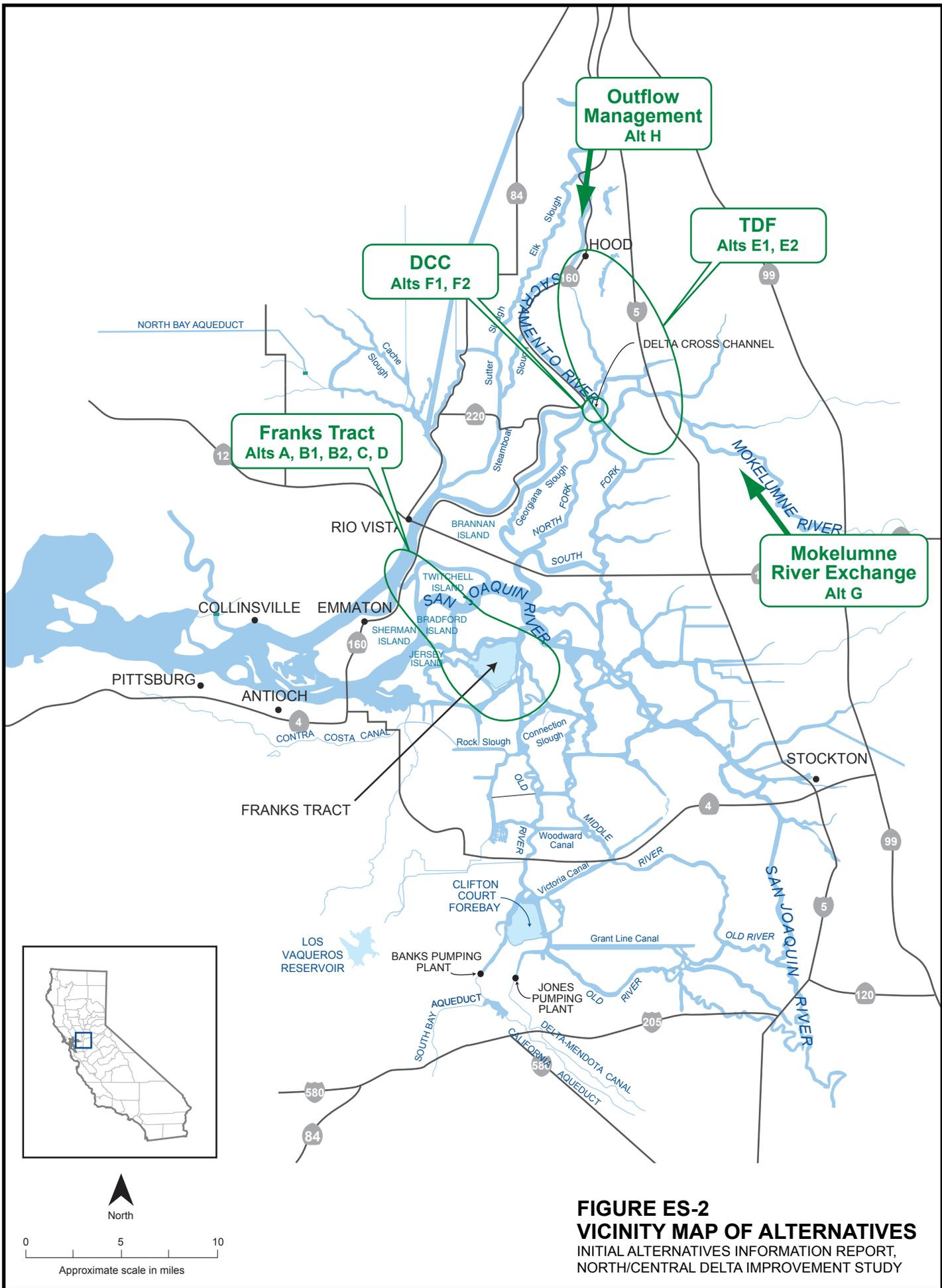


FIGURE ES-2
VICINITY MAP OF ALTERNATIVES
 INITIAL ALTERNATIVES INFORMATION REPORT,
 NORTH/CENTRAL DELTA IMPROVEMENT STUDY

This page intentionally left blank.

fisheries improvement. For NoCDIS, if an alternative did not achieve improvements in terms of water quality or fish, it was considered incomplete.

- The efficiency criterion addresses the extent to which an alternative plan is the most cost-effective means of alleviating the specified problems and realizing the specified opportunities consistent with protecting the nation's environment. At this IAIR stage of the NoCDIS, a cost comparison is presented based on the range of cost estimates developed by previous studies. Economic analysis of the alternatives will be a key component of the plan formulation phase of the NoCDIS.
- The acceptability criterion addresses the viability of an alternative with respect to acceptance by state and local entities, and compatibility with existing laws. For the IAIR stage, a qualitative assessment of acceptability is performed with respect to consistency with ongoing Delta planning activities, as well as with other Reclamation projects and policies.

Initial Alternatives Screening

The preliminary screening evaluation provides sufficient information to allow several of the initial alternatives to be removed from further consideration in the NoCDIS planning process. This ensures the resources allocated to the next phase of the analysis are focused on those alternatives that have the greatest opportunity to be successfully implemented. A summary of the IAIR conclusions for screening follows.

- Alternative A (Operable Gates on West False River) and Alternative D (Operable Gates on Three Mile Slough) are carried forward into the next phase of the NoCDIS planning process.
- Alternative E1 (Through-Delta Facility), Alternative F1 (DCC Modifications and Re-operation), Alternative F2 (DCC Re-operation), Alternative G (Mokelumne River Water Exchange), and Alternative H (Outflow Management/ Sacramento River Flow Augmentation) are not carried forward for additional consideration in combination with the NoCDIS. In addition, the other alternatives screened in Chapter 7 (Alternatives B1, B2, C, and F2) are not carried forward for additional consideration.

This page intentionally left blank.

TABLE ES-1
Summary of NoCDIS Alternatives Comparison

Alternatives	Comparison Criteria				
	Effectiveness: Water Quality Objective % decrease annual avg EC (Banks/Jones)	Effectiveness: Fish Objective	Completeness	Efficiency	Acceptability
A: Operable Gates on West False River	Low 4.8/3.6	Potential benefits to fish but possibly too small to quantify when gates are operated primarily for water quality purposes.	Relatively complete—implementation would result in benefits to water quality and fish.	Cost Range: \$35M–\$110M	High. May be complementary to other Delta improvement implementation plans. May be operated for fish benefits (e.g., Delta smelt) when water quality operations do not govern.
D: Operable Gates on Three Mile Slough	Moderate 7.7/5.3	Potential benefits to fish but possibly too small to quantify when gates are operated primarily for water quality purposes.	Relatively complete—implementation would result in benefits to water quality and fish.	Cost Range: \$75M	High. May be complementary to other Delta improvement implementation plans. May be operated for fish benefits (e.g., Delta smelt) when water quality operations do not govern.
E1: Through-Delta Facility	Highest ranking 15.2/10.5	Significant benefits to fish.	Relatively complete—implementation would result in benefits to water quality and fish.	Cost Range: \$540M	Low. This alternative is not complementary to the four Conservation Strategy Options under evaluation by BDCP participants including Reclamation. The CALFED 4,000-cfs TDF concept has been replaced by other similar proposals that are larger in capacity and length.
F1: DCC Modifications and Re-operation	Moderate 9.0/6.3	Relatively little benefit to fish.	Incomplete due to inability to meet fish objective.	Cost Range: \$230M + (significant dredging and levee modification costs)	Low. Whether the DCC can be modified without impacting adjacent land uses to be determined. More rigorous exercise of existing gates requires additional investigation. Re-operation concepts require more biological study prior to implementation. Downstream levee improvements for hydraulic capacity would require significant costs.
F2: DCC Re-operation	Low 3.1/1.9	Relatively little benefit to fish.	Incomplete due to inability to meet fish objective.	Cost Range: Higher annual O&M costs to be determined if carried forward	Moderate. More rigorous exercise of existing gates requires additional investigation.
G: Mokelumne River Water Exchange	Low 1.4/1.0	No benefit to fish due to timing of operations that corresponds to times of low fish presence.	Incomplete due to inability to meet fish objective.	Cost Range: undetermined It is expected that a cost surcharge on the water to make the exchange to acceptable by EBMUD for potential additional water treatment costs by using Sacramento River and for limiting their flexibility in water sources.	Low. This alternative has benefits, but the benefits are too few to make major improvements in the Delta. Would also require cooperation from EBMUD, which has not been involved with this alternative development to date.
H: Outflow Management/ Sacramento River Flow Augmentation	Low 3.1/2.2	No benefit to fish due to timing of operations that corresponds to times of low fish presence.	Incomplete due to inability to meet fish objective.	Cost Range: \$12M–\$18M for the annual purchase of water	Low. This alternative would require annual cooperation or long-term transfer agreements to make water available for Delta outflow management. This alternative is not likely acceptable to water users north of the Delta.

This page intentionally left blank.

Next Steps

Two alternatives will be carried forward: Alternative A (Operable Gates on West False River) and Alternative D (Operable Gates on Three Mile Slough).

The key milestones for the federal planning process, as well as the CEQA process, are listed as follows.

- NOI/NOP
- PFR (Draft and Final)
- Feasibility Report (Draft and Final)
- EIS/EIR (Draft and Final)
- ROD/Notice of Determination (NOD)

The next step in the federal planning process is the preparation of the PFR. The purpose of the PFR is to take the screening results from the initial alternatives, refine specific alternative plans to address the planning objectives; evaluate, coordinate, and compare the plans; and identify a preliminary National Economic Development (NED) plan. These immediate next steps are expected to support the Plan Formulation Phase:

- Perform a preliminary update of the costs, economic benefits, and accomplishments of alternatives carried forward from the IAIR, coordinated with DWR's ongoing Franks Tract Study. Conduct additional modeling with emphasis on facility operations optimized for fish benefits. Define more detail on specific locations of alternatives, facility configurations, geotechnical requirements, ancillary facilities, and necessary levee or adjacent land modifications.
- Refine the without-project conditions.
- Complete a preliminary site-specific analysis of potential physical, environmental, socioeconomic, and cultural effects of the comprehensive alternatives.
- Evaluate the performance of the refined comprehensive alternatives.
- Compare and screen the alternatives using criteria consistent with established federal policies and practices in water resources planning.
- Prepare the draft and final PFR.

The schedule is subject to continued appropriations and study results and may be updated as the study progresses. Commencement of the engineering, economic, and environmental studies will overlap preparation of the PFR and Feasibility Report so that an iterative approach to choosing the best alternative can be used. It is anticipated that the documentation for the NoCDIS could be completed by mid-2011.

Federal Interest

Reclamation's participation in the project could result in improved water quality, which could enhance water supply reliability for CVP contractors. In addition, the project could provide increased opportunities to protect, restore, and enhance fish populations. At this time, these are identified as potential benefits based on the preliminary analysis summarized in this IAIR. The degree and magnitude of the federal interest and the allocation of costs between the federal government and non-federal partners will be determined in the future NoCDIS Feasibility Report.

Contents

	Page
Executive Summary	ES-1
Acronyms and Abbreviations	vii
1. Introduction.....	1-1
Purpose of Report.....	1-1
Study Authorization	1-2
Need for Action.....	1-2
Study Area Location and Description	1-2
Scope of this Report.....	1-2
Report Organization.....	1-3
2. Related Studies, Projects, and Programs	2-1
CALFED	2-1
Central Valley Project.....	2-1
State Water Project.....	2-2
Coordinated Operations Agreement.....	2-2
State Water Resources Control Board, Water Rights Decision 1641	2-3
Joint Point of Diversion	2-3
Central Valley Project Operations Criteria and Plan	2-5
State Water Resources Control Board, Strategic Workplan for Activities in the San Francisco Bay/ Sacramento–San Joaquin Delta Estuary	2-6
Delta Vision	2-6
Bay Delta Conservation Plan	2-7
Delta Risk Management Strategy	2-8
Flooded Islands Pre-Feasibility Report, June 2005	2-8
South Delta Improvements Program.....	2-9
Vernalis Adaptive Management Program.....	2-10
Delta-Mendota Canal Recirculation Feasibility Study	2-10
Delta Salmon Outmigration Studies	2-11
USGS Clarksburg Fish Experiment, Fall 2006.....	2-11
Juvenile Chinook Salmon Radio-telemetry Studies in the Northern and Central Sacramento–San Joaquin Delta	2-12
3. Without-Project Conditions.....	3-1
Existing Without-Project Conditions	3-1
Water Supply	3-1
Water Quality.....	3-2
Geology.....	3-6
Flood Control.....	3-7

Contents

Sediment Transport.....	3-8
Groundwater	3-8
Transportation/Navigation	3-10
Air Quality	3-11
Noise	3-11
Fish.....	3-12
Wildlife	3-19
Vegetation.....	3-19
Land Use.....	3-20
Socioeconomics	3-20
Public Services.....	3-21
Recreation	3-22
Visual	3-24
Public Health.....	3-24
Cultural	3-25
Environmental Justice.....	3-27
Indian Trust Assets	3-28
Future Without-Project Conditions.....	3-28
Physical Environment.....	3-28
Water Resources Infrastructure/Operations.....	3-29
Biological Environment.....	3-30
Social and Economic Environment.....	3-31
Cultural Environment.....	3-32
4. Water Resources Problems, Needs, and Opportunities	4-1
Problems and Needs.....	4-1
Delta Salinity and Agricultural Drainage.....	4-2
Drinking Water Quality and the State Water Project.....	4-2
Trihalomethanes.....	4-2
Bromide.....	4-3
Pesticides, Selenium, and Mercury.....	4-3
Total Maximum Daily Loads in the Delta	4-3
Salinity in the Central Valley.....	4-3
Water Quality and Delta Fish.....	4-4
Anadromous Fish Survival	4-5
Recent Listings.....	4-5
Opportunities.....	4-5
5. Plan Formulation Approach.....	5-1
Plan Formulation Process.....	5-1
Planning Objectives	5-2
Planning Constraints	5-3
Criteria for Formulating and Evaluating Alternatives	5-3
6. Objectives and Resource Management Measures	6-1
Objective 1—Improve Water Quality.....	6-2

Measures Considered	6-2
Objective 2—Improve Fisheries Conditions.....	6-3
Measures Considered	6-3
Measures Retained for Further Consideration	6-4
7. Development of Initial Alternatives	7-1
Overview of Alternatives	7-1
Franks Tract Alternatives.....	7-2
Alternative A: Operable Gates on West False River	7-2
Alternative B1: North Levee and Two Operable Gates.....	7-7
Alternative B2: East Levee and Two Operable Gates	7-7
Alternative C: Gates on Holland Cut and Old River (Cox Alternative)	7-7
Alternative D: Operable Gates on Three Mile Slough.....	7-8
Through-Delta Alternatives	7-9
Alternative E1: Through-Delta Facility (Original CALFED Facility and Alignment)	7-9
Alternative E2: Through-Delta Facility (Alternative Concept).....	7-9
Delta Cross Channel Alternatives	7-10
Alternative F1: Delta Cross Channel Modifications and Re-operation.....	7-10
Alternative F2: Delta Cross Channel Re-operation Only	7-15
Management Alternatives	7-16
Alternative G: Mokelumne River Water Exchange.....	7-16
Alternative H: Outflow Management/Sacramento River Flow Augmentation.....	7-17
8. Comparison of Alternatives	8-1
Introduction.....	8-1
Technical Approach	8-1
Overview of Modeling Methods.....	8-2
Hydrodynamic Modeling.....	8-2
Water Quality Modeling	8-3
Particle Tracking Modeling	8-4
Alternatives Evaluation.....	8-10
Alternative A: Operable Gates on West False River	8-10
Alternative D: Operable Gates on Three Mile Slough.....	8-14
Alternative E1: Through-Delta Facility	8-17
Alternative F1: DCC Modifications and Re-operation.....	8-22
Alternative F2: DCC Re-operation	8-27
Alternative G: Mokelumne River Water Exchange.....	8-29
Alternative H: Outflow Management/Sacramento River Flow Augmentation.....	8-32
Summary Comparison of Alternatives.....	8-35
Hydrodynamics.....	8-35
Water Quality Objective	8-36

Contents

Fish Objective	8-42
Cost Estimate Summary.....	8-47
Summary	8-47
Effectiveness Criterion.....	8-47
Completeness Criterion.....	8-48
Efficiency Criterion	8-48
Acceptability Criterion.....	8-48
9. Initial Alternatives Screening	9-1
Summary of Screening Process.....	9-1
Alternative A – Operable Gates on West False River – CARRY FORWARD.....	9-2
Alternative D – Operable Gates on Three Mile Slough – CARRY FORWARD.....	9-2
Alternative E1 – Through-Delta Facility – DO NOT CARRY FORWARD.....	9-3
Alternative F1 – DCC Modifications and Re-operation – DO NOT CARRY FORWARD.....	9-4
Alternative F2 – DCC Re-operation – DO NOT CARRY FORWARD.....	9-5
Alternative G – Mokelumne River Water Exchange – DO NOT CARRY FORWARD.....	9-5
Alternative H – Outflow Management/Sacramento River Flow Augmentation – DO NOT CARRY FORWARD.....	9-6
Federal Interest.....	9-6
10. Public Involvement and Study Management	10-1
Public Involvement Program	10-1
Communication Goals and Objectives.....	10-1
Stakeholder Identification and Assessment	10-2
Study Management	10-2
Executive Committee.....	10-2
Project Management Team	10-5
Technical Work Groups	10-5
Study Coordination	10-6
11. Next Steps	11-1
Next Steps	11-1
Next Steps for the Plan Formulation Report.....	11-1
Study Schedule.....	11-2
12. References.....	12-1

Acronyms and Abbreviations

μS/cm	microSiemens per centimeter
BA	biological assessment
Bay-Delta	San Francisco Bay and Sacramento-San Joaquin Delta
BDCP	Bay Delta Conservation Plan
BNSF	Burlington Northern and Santa Fe Railroad
BO	biological opinion
B.P.	Before Present
CALFED	CALFED Bay-Delta Program
CDFG	Department of Fish and Game
CEQA	California Environmental Quality Act
cfs	cubic feet per second
COA	coordinated operations agreement
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
DCC	Delta Cross Channel
Delta	Sacramento–San Joaquin River Delta
DHCCP	Delta Habitat Conservation and Conveyance Program
DMC	Delta-Mendota Canal
DO	dissolved oxygen
DOC	dissolved organic carbon
DRMS	Delta Risk Management Strategy
DWR	Department of Water Resources
EBMUD	East Bay Municipal Utility District
EC	electrical conductivity
EIS/EIR	Environmental Impact Statement/Environmental Impact Report
EPA	Environmental Protection Agency

Acronyms and Abbreviations

ESA	Endangered Species Act
EWA	Environmental Water Account
fps	feet per second
IAIR	Initial Alternatives Information Report
IEP	Interagency Ecological Program
JPOD	Joint Point of Diversion
MWQI	Municipal Water Quality Investigations
NED	National Economic Development
NEPA	National Environmental Protection Act
NMFS	National Marine Fisheries Service
NoCDIS	North/Central Delta Improvement Study
NOD	Notice of Determination
NOI	Notice of Intent
NOP	Notice of Preparation
OCAP	Operations Criteria and Plan
PFR	Plan Formulation Report
PIP	Public Involvement Plans
POD	Pelagic Organism Decline
ppt	parts per thousand
PTM	Particle Tracking Model
Reclamation	U.S. Department of Interior, Bureau of Reclamation
ROD	Record of Decision
SDIP	South Delta Improvements Program
SJVAB	San Joaquin Valley Air Basin
SS	suspended sediments
SVAB	Sacramento Valley Air Basin
SWP	State Water Project
SWRCB	State Water Resources Control Board
taf	thousand acre-feet
TDF	Through-Delta Facility

THMs	trihalomethane
TMDLs	total maximum daily load
TWGs	Technical Working Group
USFWS	United States Fish and Wildlife
USGS	United States Geological Survey
VAMP	Vernalis Adaptive Management Program
Water Board	Regional Water Quality Control Board
WQCP	Water Quality Control Plan

Acronyms and Abbreviations

This page intentionally left blank.

CHAPTER 1

Introduction

The U.S. Department of the Interior (Interior) Bureau of Reclamation (Reclamation) and the California Department of Water Resources (DWR) are evaluating the feasibility of using conveyance and operations actions in the north and central region of the Sacramento–San Joaquin River Delta (Delta) to improve water quality and fish conditions. Specifically, Reclamation is evaluating the feasibility of these actions in the North/Central Delta Improvement Study (NoCDIS or Study).

Subject to continued appropriations and a determination of federal interest, the Study should culminate in an Environmental Impact Statement/Environmental Impact Report (EIS/EIR) and a Feasibility Report, including a Record of Decision (ROD) and Notice of Determination (NOD). Reclamation is the federal lead agency for National Environmental Policy Act (NEPA) compliance, and DWR is the state lead agency for California Environmental Quality Act compliance (CEQA).

The Initial Alternatives Information Report (IAIR or Report) for the NoCDIS is an interim document in the Feasibility Study process. The IAIR will accomplish the following:

- Describe present and future baseline conditions
- Identify problems and opportunities
- Set forth purpose and need and planning objectives
- Formulate a range of measures for the project
- Combine those measures into alternative plans

Complete alternatives that address the planning objectives are discussed in the IAIR as well as the related potential environmental impacts, and results of initial screening. A comparison of alternatives is provided to refine the alternatives that will be considered further in subsequent steps of the planning process. Based on this evaluation, the IAIR identifies a potential federal interest in the NoCDIS project.

Purpose of Report

The purpose of this IAIR (Report) is to identify the initial alternatives that will be carried forward for additional analysis in the plan formulation and feasibility phases of the Study. Reclamation has completed technical studies that provide the information required for the analyses performed in this IAIR. More detailed alternatives will be developed from these initial alternatives during the next phases of the Study.

Study Authorization

The CALFED Bay-Delta Authorization Act of 2004 (Public Law 108-361, Section 103) authorizes the Secretary of the Interior to carry out studies (via Reclamation), as follows:

- Section 103(d)(2) Conveyance
(B) North Delta Actions:
 - “(i) evaluation and implementation of improved operational procedures for the Delta Cross Channel to address fishery and water quality concerns.
 - (ii) evaluation of a screened through-Delta facility on the Sacramento River”
- Section 103(f)(1) Conveyance
(C) Franks Tract
 - “Funds may be expended for feasibility studies and actions at Franks Tract to improve water quality in the Delta.”

Reclamation chose to study these actions to determine if the actions could, alone or in combination, meet the study objectives.

Need for Action

The NoCDIS considers conveyance actions to modify hydrodynamic conditions to protect and improve water quality in the central and south Delta, protect and enhance conditions of fish species of concern in the west and central Delta, and achieve greater operational flexibility for pump operations in the south Delta.

Study Area Location and Description

The Study area, shown in Figure 1-1, involves sections of the north, central, and south Delta, including the waterways around Franks Tract, the Sacramento River, the South Fork of the Mokelumne River, the Delta Cross Channel, and the lower San Joaquin River. Much of the land within the Study area is subject to agricultural activities, while the waterways provide recreational opportunities; valuable wildlife habitat; and serve as major residential, municipal, and agricultural water supplies to much of the state.

Scope of this Report

The primary purpose of this IAIR is to describe the formulation of initial alternatives to address planning objectives established for the NoCDIS. From these initial alternatives, detailed alternative plans will be developed for further evaluation during plan formulation.

This report:

- Describes existing and likely future water resources and related conditions in the Study area, as well as related problems, needs, and opportunities being addressed in the Study.
- Develops planning objectives to address identified problems, needs, and opportunities to support these planning objectives.
- Identifies the planning constraints, guiding principles, and criteria for the Feasibility Study.
- Identifies and evaluates individual water resources management measures to address each of the planning objectives:
 - From the identified management measures, formulate a set of concept plans that represent a range of actions that could address the planning objectives.
 - From the concepts, identify a recommended set of initial alternatives to be further developed in the Feasibility Study.
 - Perform coarse screening of the initial alternatives in terms of completeness, effectiveness, efficiency, and acceptability.
 - Identify potential major future actions for the Feasibility Study.

Report Organization

The NoCDIS IAIR is organized into 12 chapters:

- Chapter 1, Introduction, includes the purpose and need, background information, study authorization, and scope of the report.
- Chapter 2, Related Studies, Projects, and Programs, includes relevant studies that overlap or interrelate to the project area or issues.
- Chapter 3, Without-Project Conditions, details the existing and future conditions if no project alternative is implemented.
- Chapter 4, Water Resources Problems, Needs, and Opportunities, includes a detailed description of the water resource problems, needs, and opportunities in the Delta.
- Chapters 5 through 9 contain the details of the plan formulation approach and development, initial alternatives considered, and the alternatives that will be carried forward into subsequent phases of the federal planning process.
- Chapters 10 through 11 include public involvement, Study management, and next steps.
- Chapter 12 contains a complete listing of references utilized in the IAIR.

This page intentionally left blank.

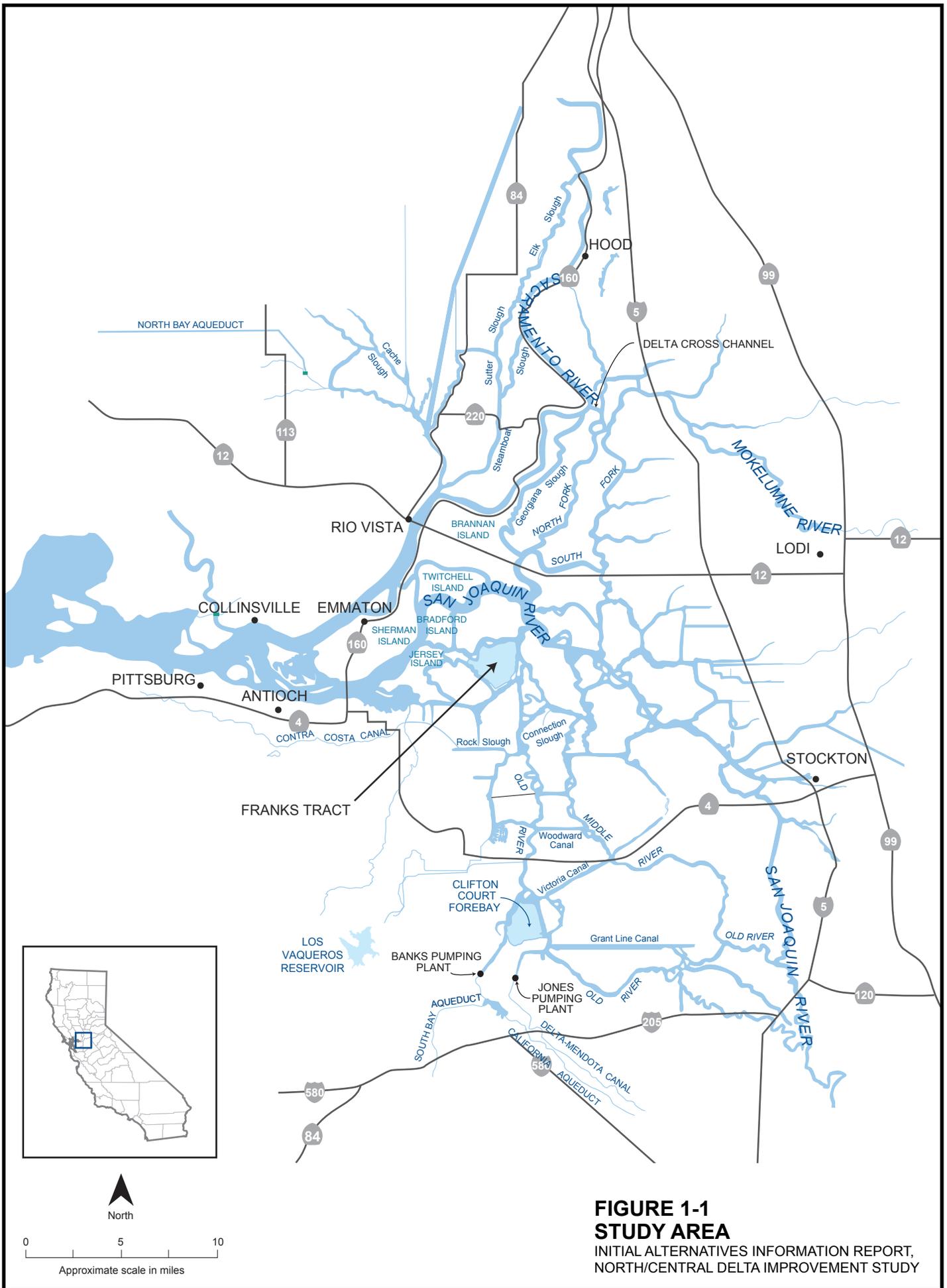


FIGURE 1-1
STUDY AREA
 INITIAL ALTERNATIVES INFORMATION REPORT,
 NORTH/CENTRAL DELTA IMPROVEMENT STUDY

This page intentionally left blank.

CHAPTER 2

Related Studies, Projects, and Programs

This chapter summarizes the related activities of various federal, state, and local agencies in the Study area. Many of these entities, including Reclamation and DWR, are currently performing studies, projects, and programs that are important to the future of the Delta.

Chapter 2 is organized by starting with the CALFED Bay-Delta Program that initiated the NoCDIS and led to authorization for study by Reclamation. This chapter describes the federal and state water projects, and the broad regulations and agreements relevant to Delta operations; describes major ongoing long-term Delta planning processes; and concludes with specific recent or ongoing studies and programs relevant to the NoCDIS planning process.

CALFED

CALFED is a collaborative effort among 25 state and federal agencies and representatives of California's environmental, urban, and agricultural communities to improve water quality, fish and wildlife habitat, and water supply reliability in the San Francisco Bay/ Sacramento–San Joaquin River Delta, the hub of the state's water distribution system. The lead CALFED agencies released the Final Programmatic EIS Preferred Alternative on July 21, 2000, followed by the signing of the CALFED Bay-Delta Programmatic ROD on August 28, 2000, establishing a 30-year plan for improving water supplies and the Bay-Delta ecosystem.

The Preferred Program Alternative of CALFED is an integrated plan to achieve the objectives determined by CALFED. Conveyance is one of eight program elements designed to accomplish the objectives of the plan. The Conveyance element includes the Franks Tract Project, Delta Cross Channel studies, and the Through-Delta Facility (TDF). As described in Chapter 1, Reclamation was authorized to carry out feasibility studies for these components of the Conveyance element by the CALFED Bay-Delta Authorization Act of 2004.

Central Valley Project

The Central Valley Project (CVP) encompasses 35 counties in an area about 500 miles long and 60 to 100 miles wide. It contains some of the nation's largest reservoirs, including Shasta and San Luis. The CVP is a system of 20 dams and reservoirs, 500 miles of major canals, hydropower plants, pumping plants, and other facilities located mainly in California's Sacramento and San Joaquin valleys.

The CVP manages about 9 million acre-feet of water each year and delivers about 7 million acre-feet to irrigate some 3 million acres of prime farmland annually in six of the top 10 agricultural counties in California, the nation's leading farm state. Some two-thirds of California's population receive their drinking water from the San Joaquin-Sacramento River Bay-Delta, and the Region helps maintain Delta water quality standards by providing water from its reservoirs to flush out salinity. The CVP irrigates about one-third of all lands Reclamation irrigates in the 17 western states, and one-sixth of the irrigated land in the U.S. CVP water is also critical to California's poultry, beef, and dairy industries. The Central Valley's annual farm production exceeds the total value of all the gold mined in California since 1848.

Some 600,000 acre-feet of water each year goes toward urban and industrial use, serving some 2 million people, and 800,000 acre-feet are dedicated for fish and wildlife purposes. Eleven CVP hydroelectric generators produce about 5.5 billion kilowatt hours of clean, renewable hydropower each year, enough energy to supply the needs of some 1.5 million people. Flood control is one of the primary CVP purposes. The CVP ranks first among Reclamation projects in value of flood damage prevention, having averted more than \$5 billion dollars in flood damage since 1950. Millions of people also enjoy boating, skiing, swimming, fishing, camping, and other recreation at the Region's reservoirs.

State Water Project

The State Water Project (SWP) is a state-built water and power supply and conveyance system operated by the DWR. The extensive system of pumping and power plants, reservoirs, canals, and pipelines serves 29 water agencies and more than 23 million people. Water is conveyed to the Bay Area, Central Valley, and Southern California, serving numerous water districts and allowing the region's tremendous growth over past decades.

Water diversions during dry years have raised environmental concerns, primarily threats to the San Joaquin River spring-run salmon and Delta smelt, as pumping stations divert water that normally flows to the Pacific Ocean. In addition, balancing the water needs of the Delta region and Southern California with the effects of saltwater intrusion into the Delta has led to drinking water concerns.

Coordinated Operations Agreement

The Coordinated Operation Agreement (COA) between the United States of America and DWR to operate the CVP and the SWP was signed in November 1986. Congress, through Public Law 99-546 authorized and directed the Secretary to execute and implement the COA. The COA defines the rights and responsibilities of the CVP and SWP with respect to in-basin water needs and provides a mechanism to account for those rights and responsibilities.

Under the COA, Reclamation and DWR agree to operate the CVP and SWP under balanced conditions in a manner that meets Sacramento Valley and Delta needs, while maintaining their respective annual water supplies as identified in the COA. Balanced conditions are defined as periods when the two Projects agree that releases from upstream reservoirs, plus unregulated flow, approximately equal water supply needed to meet Sacramento Valley in-basin uses and Project exports. Coordination between the two projects is facilitated by implementing an accounting procedure based on the sharing principles outlined in the COA. During balanced conditions in the Delta when water must be withdrawn from storage to meet Sacramento Valley and Delta requirements, 75 percent of the responsibility to withdraw from storage is borne by the CVP and 25 percent by the SWP. The COA also provides that during balanced conditions when unstored water is available for export, 55 percent of the sum of stored water and the unstored export water is allocated to the CVP, and 45 percent is allocated to the SWP. Although the principles were intended to cover a broad range of conditions, changes introduced by past biological opinions (BOs), State Water Resources Control Board (SWRCB) D-1641, and Central Valley Project Improvement Act (CVPIA) were not specifically addressed by the COA. However, these variances have been addressed by Reclamation and DWR through mutual informal agreements.

State Water Resources Control Board, Water Rights Decision 1641

The SWRCB issued Water Right Decision 1641 (D-1641) on December 29, 1999, revised it on March 15, 2000, and amended it on December 13, 2006. SWRCB D-1641 is the water right decision implementing the 1995 Delta Water Quality Control Plan (WQCP) objectives and responsibility for meeting those objectives. SWRCB D-1641 also approved Reclamation's and DWR's petition to add each other's Delta pumping plant as additional points of diversion for the CVP and SWP in the south Delta and approved a petition to change and consolidate places and purposes of use of water under certain CVP permits. The final phase of implementation focused on how water rights holders in the Sacramento Valley should contribute to meeting the 1995 Delta WQCP objectives. A negotiated settlement resolved this issue by creating the Sacramento Valley Water Management Agreement and Program. D1641 applies to DWR and Reclamation water right permits through terms and conditions affecting SWP and CVP operations. The SWRCB periodically reviews the Delta Plan and amends it as necessary, and reserves the right to issue future decisions assigning responsibility for meeting water quality standards.

Joint Point of Diversion

SWRCB D-1641 granted Reclamation and DWR the ability to use/exchange each Project's diversion capacity capabilities to enhance the beneficial uses of both

Projects. The SWRCB conditioned the use of Joint Point of Diversion (JPOD) capabilities based on a staged implementation and conditional requirements for each stage of implementation. The stages of JPOD in SWRCB D-1641 include the following:

- Stage 1—for water service to Cross Valley Canal contractors, Tracy Veterans Cemetery, and Musco Olive, and to recover export reductions taken to benefit fish.
- Stage 2—for any purpose authorized under the current project water right permits.
- Stage 3—for any purpose authorized up to the physical capacity of the diversion facilities.

Each stage of JPOD has regulatory terms and conditions that must be satisfied in order to implement JPOD. All stages require a response plan to ensure water levels in the south Delta will not be lowered to the injury of local riparian water users (Water Level Response Plan). All stages require a response plan to ensure the water quality in the south and central Delta will not be significantly degraded through operations of the JPOD to the injury of water users in the south and central Delta.

Stage 2 has an additional requirement to complete an operations plan that will protect fish and wildlife and other legal users of water. This is commonly known as the Fisheries Response Plan. A Fisheries Response Plan was approved by the SWRCB in February 2007, but as it relied on the 2004 and 2005 BOs, the Fisheries Response Plan will need to be revised and re-submitted to the SWRCB at a future date.

Stage 3 has an additional requirement to protect water levels in the south Delta under the operational conditions of Phase II of the South Delta Improvements Program (SDIP), along with an updated companion Fisheries Response Plan. Reclamation and DWR intend to apply all response plan criteria consistently for JPOD uses as well as water transfer uses.

In general, JPOD capabilities will be used to accomplish four basic CVP-SWP objectives:

- When wintertime excess pumping capacity becomes available during Delta excess conditions and total CVP-SWP San Luis storage is not projected to fill before the spring pulse flow period, the project with the deficit in San Luis storage may elect to use JPOD capabilities. Concurrently, under the CALFED ROD, JPOD may be used to create additional water supplies for the Environmental Water Account.
- When summertime pumping capacity is available at Banks Pumping Plant and CVP reservoir conditions can support additional releases, the CVP may elect to use JPOD capabilities to enhance annual CVP south of Delta water supplies.

- When summertime pumping capacity is available at Banks Pumping Plant or Jones Pumping Plant to facilitate water transfers, JPOD may be used to further facilitate the water transfer.
- During certain coordinated CVP-SWP operation scenarios for fishery entrainment management, JPOD may be used to shift CVP-SWP exports to the facility with the least fishery entrainment impact while minimizing export at the facility with the most fishery entrainment impact.

Central Valley Project Operations Criteria and Plan

The long-term CVP Operations Criteria and Plan (OCAP), prepared in 2004 by Reclamation and DWR, serves as a baseline description of the facilities and operating environment of the CVP and SWP. The OCAP identifies the many factors influencing the physical and institutional conditions and decision making process under which the projects currently operate. Regulatory and legal requirements are explained; and alternative operating models and strategies are described. The immediate objective is to provide operations information for the Federal Endangered Species Act (FESA), Section 7 consultation.

In 2005, results of annual surveys designed to indicate population levels of several pelagic organisms, including the Delta smelt, were showing a precipitous decline. Reclamation reinitiated FESA consultation on OCAP with the U.S. Fish and Wildlife Service (USFWS) based on new information regarding the Delta smelt, including the apparent decline in the population.

The consultation process requires the USFWS to determine whether or not the operation of the projects would jeopardize the continued existence of the Delta smelt, and to identify reasonable and prudent measures for the action agency to implement, thereby minimizing any adverse effects of the projects. Until the consultation process is complete, Reclamation is implementing the remedial actions required by a December 2007 court order (Federal District Court, Eastern District of California, in Natural Resources Defense Council [NRDC] v. Kempthorne).

However, the Court's remedial actions have limitations. These actions affect the operation of the pumps, which is only one of the factors affecting the Delta smelt. Also, because these actions were developed in litigation, they have not been subject to a careful scientific peer review. Therefore, it is uncertain whether they will be effective in protecting the smelt and be incorporated into the new OCAP.

Delta issues affecting salmon, steelhead, and sturgeon are likely to come to the forefront in the coming months, based on a parallel lawsuit against the National Marine Fisheries Service (NMFS). Reinitiation of FESA consultation on OCAP with the NMFS is also in process.

State Water Resources Control Board, Strategic Workplan for Activities in the San Francisco Bay/Sacramento–San Joaquin Delta Estuary

To further its WQCP goals for the Delta and San Francisco Bay, the SWRCB (together with the Central Valley Regional Water Quality Control Board and San Francisco Bay Regional Water Quality Control Board [Water Boards]) approved the Strategic Workplan for Activities in the San Francisco Bay/Sacramento–San Joaquin Delta Estuary (SWRCB, 2008). The Workplan is a 5-year action plan “to address the water supply and environmental crisis in the Delta” (SWRCB, 2008). There are nine general categories of Workplan activities:

- Water quality and contaminant control
- Comprehensive monitoring plan
- South Delta salinity and San Joaquin River flow objectives
- Suisun Marsh management, preservation, and restoration
- Comprehensive review of the Bay-Delta WQCP, water rights, and other requirements to protect fish and wildlife beneficial uses and the public trust
- Activities to ensure that the SWP and CVP methods of diversion in the Delta are reasonable, beneficial, and protect the public trust
- Water right compliance, enforcement, and other activities to ensure adequate flows to meet water quality objectives
- Water use efficiency
- Other activities

As described in the Workplan, these nine elements cover a range of actions that (1) implement the Water Boards’ core water quality responsibilities, (2) continue meeting prior Water Board commitments, (3) are responsive to the priorities identified by the Governor and the Delta Vision Blue Ribbon Task Force (described in the following), and (4) build on existing processes such as the Bay Delta Conservation Plan (BDCP) (described in the following text).

Delta Vision

The Delta Vision process was initiated by the Governor of the State of California through Executive Order S-17-06 establishing an independent Blue Ribbon Task Force responsible for the development of a durable vision for sustainable management of the Delta. As part of the process, a Cabinet-level Delta Vision Committee was appointed to oversee the process, along with the appointment by the Committee of a 43-member Stakeholder Coordination Group and two Science

Advisors. The work of the Task Force includes two phases, the Delta Vision, which was completed in December 2007 and the Strategic Plan, which was completed in October 2008.

The Delta Vision consists of 12 integrated and linked recommendations that are meant to be implemented together over time. Key recommendations included significant increases in conservation and water system efficiency, new water conveyance and storage facilities, and new governance for the Delta region. The Delta Vision also recommended seven near-term actions that include improving flood protection, ecosystem restoration, and water supply and reliability.

Consistency with the goals and objectives of the Delta Vision recommendations will be considered as the NoCDIS federal planning process advances.

Bay Delta Conservation Plan

The BDCP is a Habitat Conservation Plan and Natural Communities Conservation Plan being prepared to meet the FESA, and California Endangered Species Act (CESA), respectively, for water operations and management activities in the Delta. Specifically, the State of California DWR will seek an incidental take permit (ITP) under Section 10 of the FESA for continued water operations and deliveries through the Delta. Mirant Power, Incorporated will seek an ITP under Section 10 of the FESA for the diversion of water for power operations in the Delta. The BDCP will also be used, if feasible, by Reclamation as the basis for FESA Section 7 compliance, resulting in the issuance of BOs and Incidental Take Statements to Reclamation for their participation and implementation of the BDCP.

These incidental take authorizations will allow for the incidental take of threatened and endangered species resulting from covered activities and conservation measures associated with water operations of the SWP and CVP, including facility improvements and maintenance activities, operational activities related to water transfers, new Delta conveyance facilities, and habitat conservation measures included in the BDCP. Federal and state water contractors participating in the BDCP include Metropolitan Water District of Southern California, Kern County Water Agency, Santa Clara Valley Water District, Zone 7 Water Agency, San Luis Delta & Mendota Water Authority, and Westlands Water District. BDCP conservation measures will likely include new and improved water supply conveyance actions and habitat conservation as well as the associated monitoring and adaptive management. A Notice of Preparation (NOP) of a joint EIS/EIR was issued by DWR on March 17, 2008. A Notice of Intent (NOI) to prepare an EIS/EIR and conduct scoping meetings was issued by co-lead agencies Reclamation, USFWS, and NMFS on April 15, 2008.

While the NoCDIS is narrower in geographic scope, it is expected to have common objectives, stakeholders, and beneficiaries as the BDCP. Consistency and coordination with the BDCP will be considered as part of the NoCDIS federal planning process.

Delta Risk Management Strategy

A major need for the state is to determine how to make the Delta sustainable in the future. The 2000 CALFED ROD presented its Preferred Program Alternative that described actions, studies, and conditional decisions to help manage the Delta. The Preferred Program Alternative for Stage 1 implementation included the completion of a Delta Risk Management Strategy (DRMS) that would examine sustainability of the Delta, and would assess major risks to the Delta resources from floods, seepage, subsidence, and earthquakes. The DRMS would also evaluate the consequences of these risks and develop recommendations to manage the risks.

Assembly Bill 1200 (California Water Code Section 139.2 et seq.) requires that DWR evaluate the potential impacts on water supplies derived from the Delta based on 50-, 100-, and 200-year projections for each of the following possible impacts: subsidence, earthquakes, floods, climate change, and sea level rise, or a combination of the above. The DRMS work will provide the majority of this required information. The report was provided to the Legislature in February 2008.

Technical analysis in regard to levee stability and seismic vulnerability completed by DRMS will be considered in the conceptual design phase of NoCDIS alternatives.

Flooded Islands Pre-Feasibility Report, June 2005

DWR completed the Flooded Islands Pre-Feasibility Report in June 2005. This report initially was undertaken to evaluate improvements in ecosystem value, water quality, and recreational opportunities at Lower Sherman Lake (owned by CDFG), Big Break (owned by East Bay Regional Park District), and Franks Tract (owned by California Department of Parks and Recreation) through modification of existing, but degraded, levees. These modifications potentially would inhibit salt trapping while restoring tidal marsh habitat, especially during drier times of the year.

Since 2001, the flooded islands study has been revised several times as new physical and social data are collected through modeling and information gathering and with development of preliminary design concepts. The study was modified to assess potential work at more than one island and associated improvements in adjacent areas; re-creation of dendric channels to provide ecological benefit for native plants, fish, and wildlife; cost-effective restoration and modification of shoreline levees and adjacent channels; and maintaining existing recreation, aesthetics, and flood control at each island.

Numerous proposed alternative design concepts were evaluated and screened using pre-model screening tools, and by conducting water quality modeling runs using the Resource Management Associates Bay-Delta model—a numerical model of flow and salinity transport that determines potential velocity, stage,

channel flow, electrical conductivity, and residence time. Preferred alternatives of the pre-feasibility study must undergo further analysis, and cost estimates must be developed if they are to be included in the NoCDIS feasibility study.

The results of this report led to proposed program development next steps, guidelines for a pilot program, and identification of preliminary alternative pilot projects, ultimately resulting in DWR initiating the Franks Tract Study.

South Delta Improvements Program

SDIP is one element of the preferred CALFED Program that was identified in the CALFED ROD as part of the programmatic solution to achieve the goals of water supply reliability, water quality, ecosystem restoration, and levee system integrity. The program is described in detail in the December 2006 SDIP Final EIS/EIR. The SDIP alternatives consist of two major components: a physical/structural component and an operational component. The SDIP physical/structural component includes the construction and operation of permanent operable gates at up to four locations in south Delta channels to protect fish and meet the water level and, through improved circulation, water quality needs for local irrigation diversions; channel dredging to improve water conveyance; and modification of 24 local agricultural diversions. The operational component considers raising the permitted diversion limit into the SWP Clifton Court Forebay from 6,680 cubic feet per second (cfs) to 8,500 cfs.

The proposed project is to be implemented in two stages, the first being the physical/structural component and the second relating to the operational changes. Only Stage 1 is proposed at this time. Stage 2 is being deferred and will include making a decision on the operational component of SDIP.

Stage 1 will include making a decision on the physical/structural component. The physical/structural component includes:

- Replacing the seasonal barrier with a permanent operable fish control gate on the head of Old River
- Replacing the three seasonal temporary agricultural control barriers with permanent operable gates on Middle River, Grant Line Canal, and Old River
- Dredging portions of Middle River and Old River and possibly West, Grant Line, Victoria, and North Canals to improve flows in the south Delta channels

Components of the SDIP are expected to be implemented and will need to be considered in the future condition for the NoCDIS planning process. Consideration is particularly relevant with respect to water quality analysis and hydrodynamics in the south Delta.

Vernalis Adaptive Management Program

The San Joaquin River Agreement (SJRA) includes a 12-year experimental program providing for increased flows and decreased Delta exports in the lower San Joaquin River during a 31-day pulse flow period during April through May. It also provides for the collection of experimental data during that time to further the understanding of the effects of flows, exports, and the Head of Old River Barrier on salmon survival. This experimental program is commonly referred to as the Vernalis Adaptive Management Program (VAMP). The SJRA also provides water for flows at other times on the Stanislaus, Merced, and lower San Joaquin Rivers. The SJRA establishes a management and technical committee to oversee, plan, and coordinate implementation of activities required under the SJRA.

Reclamation, DWR, USFWS, DFG, and NMFS are signatories to the SJRA; other signatories include San Joaquin River water rights (SJRWR) holders, CVP and SWP water contractors, and other stakeholders. The signatory SJRWR holders formed the San Joaquin River Group Authority to coordinate implementation of their responsibilities under the SJRA. Under the SJRA, Reclamation and DWR purchase water for VAMP flows from the SJRWR holders of up to 110,000 acre feet (af) may be provided for VAMP during April-May with an additional 27,500 af that may be provided at other times. In certain “double-step” years, up to an additional 47,000 af may need to be acquired to fully meet VAMP flow objectives. This water would be provided under supplemental agreements separate from the SJRA. The SJRA will expire on December 31, 2009, unless extended pursuant to the conditions of the agreement.

Delta-Mendota Canal Recirculation Feasibility Study

The Delta-Mendota Canal Recirculation Feasibility Study is identified in its authorizing legislation as part of Reclamation’s overall Program to Meet Standards. The study will determine whether it is possible to provide flexibility in meeting the water quality and flow standards for which CVP has responsibility. Through the use of excess capacity in the export pumping and conveyance facilities, this study will determine whether required water quality and flow standards could be obtained, and, if so, under what range of conditions. Through coordination with regulating agencies, data points within the San Joaquin River and Delta will be selected to track the effects this pumping will have at these locations. Additionally, the study will determine if this process could result in a reduced demand on water from New Melones Reservoir (currently used to meet water quality and flow requirements) and assist the Secretary of the Interior in meeting any obligation to CVP water contractors using the New Melones Reservoir.

Delta Salmon Outmigration Studies

To assess possible effects of Delta Cross Channel (DCC) gate operations on migrating adult Chinook salmon, the United States Geological Survey (USGS), Reclamation, CDFG, and USFWS collaborated on a pilot study in 2000.

The purpose of this pilot study was to compare abundance and migration timing of adult Chinook salmon in the Sacramento River, DCC, and Georgiana Slough with the DCC gates open and closed using hydroacoustic, sonic tagging, and fyke trap data. The pilot study was expanded in 2001 by increasing the sampling effort and duration. A combination of tidal hydraulic and water quality modeling, together with intensive tidal flow and electrical conductivity (EC) data collection throughout the central Delta channels by the USGS, is being used to evaluate the effects of DCC closure and possible re-operation.

The results of these initial DCC investigations are being used to plan an even more extensive series of flow, EC, and juvenile fish movement measurements during winter 2008-2009.

Possible DCC re-operation alternatives might involve: (1) opening at least one gate during low-flow conditions (to reduce salinity effects), (2) diurnal or tidal cycle opening (to allow some diversions when fish are reduced in density), (3) upstream flow baffles (dikes) to redirect fish away from the DCC gates, or (4) possible fish screens in front of (or attached to) the DCC gates.

USGS Clarksburg Fish Experiment, Fall 2006

USGS conducted experimental measurements of secondary currents and juvenile fish movement patterns in the Clarksburg Bend, located upstream of the DCC.

The experiment, funded by DWR and Reclamation, examined bend hydrodynamics/salmon behavior interaction to generate non-homogeneous salmon smolt spatial distributions. It also provided a means to develop behavior sub-models for inclusion in individual-based Particle Tracking Models.

In addition, the experiment provided initial estimates of mortality rates in selected channels, and presented an opportunity to test equipment and analytical techniques.

The two-part experiment involved fish tagging and release and data collection. The first part involved 250 acoustically tagged salmon smolts released at two Sacramento River discharge rates (low and medium). Fish were released during each discharge level throughout the day (morning, day, evening, night). The second part of the experiment included 240,000 Vemco-tagged fish, separated into six groups. These fish served as targets for hydroacoustics.

Juvenile Chinook Salmon Radio-telemetry Studies in the Northern and Central Sacramento–San Joaquin Delta

Protecting juvenile anadromous salmonids and the simultaneous conveyance of a reliable water supply through the Delta requires a comprehensive understanding of the interaction between fish migration and environmental conditions in the Delta. Detailed data on fish behavior, migratory pathways, reach-specific survival, and point-source mortality in relation to complex hydrodynamic conditions in the Delta have been lacking. However, recent advances in acoustic telemetry have been demonstrated to allow use of the technology to determine juvenile salmon migration characteristics.

Extensive field tests of new acoustic hardware during 2005 and 2006 verified the utility of the equipment for Delta studies. Miniature acoustic transmitters (0.75-gram weight in air) were surgically implanted in juvenile salmon as small as 94-millimeter fork length, which approximates the size of many wild smolts. Acoustic receivers developed for this research project permitted fixed-station monitoring of acoustic-tagged smolts passing strategic sites within Delta channels and mobile telemetry monitoring. These single receivers can also be used in conjunction with planned Delta studies using 3-D fish positioning telemetry hardware for cost-effective use of acoustic-tagged salmon in multiple concurrent research projects.

Without-Project Conditions

Identifying the magnitude of potential environmental impacts resulting from a proposed project or program is based on an analysis of existing conditions, as well as an interpretation of how those conditions could change in the future. Chapter 3 presents both the existing and future without-project conditions within the Study area.

Existing Without-Project Conditions

Per state and federal laws, environmental impacts must be evaluated based on conditions both with and without the proposed project. The following subsections briefly describe the existing conditions of various environmental resources in the Study area.

Water Supply

California's water supplies come from surface water and groundwater sources that vary in distribution and volume depending on annual climatic conditions. Natural runoff to the Delta is lowest in the summer and fall months when the weather is dry. Because agricultural and urban demands are highest during the summer, there is an imbalance between when water supply is available and when it is most needed. Therefore, storage reservoirs are relied upon to consistently meet water supply demands. Additionally, surface supplies are also used to provide freshwater flows for environmental purposes below reservoirs.

California water supply development includes local projects, the SWP, and the CVP. The SWP and CVP store and release water upstream of the Delta, and deliver water from the Delta to areas within and south of the Delta. All of the SWP and CVP water stored upstream of the Delta that is appropriated for use south of the Delta must pass through the Delta and the SWP or CVP export facilities. Additionally, approximately 1,800 siphons and small pumps are used to divert water from Delta channels to Delta islands for agricultural uses.

A third substantial diverter of Delta water is Contra Costa Water District (CCWD). CCWD has CVP service contracts and their own water rights. Under these rights, CCWD diverts water from Rock Slough and from Old River near the Highway 4 Bridge that serves as the pumping plant for Los Vaqueros Reservoir. A new intake is being constructed on Victoria Canal; this project is known as the Alternative Intake Project. This intake project is designed for fish protection and water quality improvements.

Various water quality and flow objectives have been established to ensure that the quality of Delta water is sufficient to satisfy all designated beneficial uses as defined by the SWRCB. Implementation of these objectives requires that

limitations be placed on water supply operations that affect Delta salinity levels, particularly operation of the SWP and CVP. To a varying degree, the SWRCB reserves jurisdiction to establish or revise appropriative water rights for salinity control, protection of fish and wildlife, protection of vested water rights, and to coordinate between the major water supply projects.

Regulatory constraints on SWP and CVP operations restrict the projects' ability to meet the full demand of CVP and SWP water contracts. Regulatory limits are based on Delta outflow requirements, salinity objectives, export/inflow limits, and permitted or physical export pumping capacity. Within the regulatory constraints, tradeoffs between water supply and water quality remain key considerations involving the operation of CVP/SWP and Delta conditions. Higher Delta outflows reduce seawater intrusion into the central Delta and improve water quality of SWP and CVP exports, but increasing Delta outflow with upstream storage releases has water supply quantity implications. SWP and CVP exports may be reduced in the fall months to reduce the salinity of exports, even though this reduces the volume of water supplied.

The DCC is a CVP facility that is a 1-mile-long gated diversion channel connecting the Sacramento River near Walnut Grove with Snodgrass Slough. The location of the DCC is shown in Figure 1-1. Depending on tidal conditions, the capacity of the DCC can be 9,000 cfs or greater during high-flow conditions. When the gates are open, water flows from the Sacramento River to natural channels in the lower Mokelumne River and San Joaquin River and toward the interior Delta. Reclamation operates the DCC to improve the transfer of water from the Sacramento River to its Jones Pumping Plant (for export south of the Delta) and to improve water quality in the south Delta by reducing seawater intrusion from the west. The gates are closed during high flows in the Sacramento River to reduce scour and potential flooding of Mokelumne River channels. In addition, the gates are closed from February 1 through May 20 for fish protection. The gates may be closed for an additional 45 days between November and January, and up to 14 days between May 21 and June 15 for further fishery protection.

Water Quality

Delta waters support municipal, agricultural, recreational, industrial, and fish and wildlife uses, each with associated water quality requirements and concerns. These uses are considered "impaired" by contaminants. Various programs are being implemented to reduce these "impairments."

Water quality conditions in the Delta are influenced by natural environmental processes, water management operations, and waste discharge practices. Delta water quality conditions vary dramatically because of annual differences in runoff and water storage releases, and seasonal fluctuations in managed Delta flows. None of these water quality variables acts independently, and their interactions are complex. Concentrations of materials in river inflows are related to stream flow volume and season. Transport and mixing of materials in Delta channels are

related to river inflows, tidal flows, agricultural diversions, drainage flows, wastewater effluents, exports, and cooling water flows. Concentrations of water quality constituents of concern tend to be higher in Delta exports than in Sacramento River inflow. In the Delta region, the SWRCB is developing and implementing total maximum daily loads (TMDLs) for salt and boron, low dissolved oxygen (DO), organophosphate pesticides, pathogens, mercury, selenium, and polychlorinated biphenyls (PCBs).

Delta water is diverted for agricultural crop and livestock production at more than 1,800 siphons. Agricultural drainage water is returned to the Delta through pumping stations operated independently by Reclamation districts. Industrial intakes and discharges also occur near Sacramento, Stockton, and Antioch.

The Delta is a source of drinking water for approximately 23 million Californians. When chlorine is added to municipal water supplies to kill disease-causing bacteria, certain disinfection byproducts are formed, among them trihalomethanes (THMs). Suspected of being carcinogenic in humans, THMs result from complex chemical reactions between naturally occurring organic substances, the chlorine added for disinfection purposes, and bromine compounds in seawater. Therefore, projects with the potential to compromise the quality of the Delta as a drinking water source may result in the need for more extensive water treatment with an associated increase in THM concentrations.

Dominant water quality variables that influence habitat and food-web relationships in the Delta are discussed in the following text, and include temperature, suspended sediments (SS) and associated light levels, DO, salinity, ammonia, and pesticides (diazinon and chlorpyrifos). Key constituents monitored in municipal water use are bromine concentrations, dissolved organic carbon (DOC), and concentrations of THMs or other chemical byproducts formed during water disinfection/treatment.

Temperature

Temperature governs the rate of biochemical processes, and is considered a major environmental factor in determining organism preferences and behavior. Fish growth, activity, and mortality are all related to temperature. Delta water temperatures are determined predominantly by weather and, to a lesser extent, by water management activities. Also, the maximum (saturated) concentration of DO in water is lower at higher temperatures, making it more difficult for fish to take in oxygen.

Suspended Sediments

Suspended sediments are a general indicator of surface erosion and runoff into water bodies or re-suspension of bottom sediment materials. Following major storms, water quality is often degraded by inorganic and organic solids and attached contaminants such as metals, nutrients, and agricultural chemicals that are re-suspended or introduced in runoff. Such episodes are relatively infrequent, persist for a limited time, and are often not detected by regular water quality

monitoring programs. The attenuation of light in Delta waters is controlled by SS concentrations. SS concentrations are often elevated in the entrapment zone¹ as a result of increased flocculation (i.e., aggregation of particles) in the estuarine salinity gradient. High winds and tidal currents also contribute to increased SS in the Delta.

Dissolved Oxygen

DO is often used as an indicator of the balance between sources of oxygen (e.g., aeration and photosynthesis) and oxygen-consuming processes (decay and respiration). The DO saturation concentration is affected by temperature, and DO concentration often varies diurnally. DO concentrations in Delta channels are not generally considered to be a problem, except near Stockton and in some dead-end sloughs. DO concentrations in agricultural drainage samples from DWR's Municipal Water Quality Investigations (MWQI) Program are sometimes slightly depressed, indicating the presence of a large quantity of organic material (measured by DOC).

In 1986, approximately 40 miles of the lower San Joaquin River from Vernalis to Stockton were identified as unsupportive of fishery-related beneficial uses due to poor water quality. In addition, several recent reports have listed the 14-mile Stockton to Turner Cut reach as water-quality impaired resulting from low DO. A TMDL for DO in the San Joaquin River was approved by the SWRCB in 2005.

Electrical Conductivity

EC is a general measure of salinity and is the most commonly measured variable in Delta waters. EC is generally considered a conservative parameter not subject to sources or losses internal to a water body. Therefore, changes in EC values can be used to interpret the movement of water and the mixing of salt in the Delta. EC values increase with evaporation, decrease with rainfall, and may be elevated in agricultural drainage flows. Because EC changes with temperature, Delta EC measurements are standardized to 25°C.

The south Delta salinity objectives for agricultural uses are specified at: (1) San Joaquin River at Vernalis, (2) San Joaquin River at Brandt Bridge, (3) Old River near Middle River, and (4) Old River at Tracy Boulevard. The 1995 WQCP salinity objectives at Vernalis specify that the maximum EC will be 700 microSiemens per centimeter ($\mu\text{S}/\text{cm}$) during the irrigation season (April through August) and 1,000 $\mu\text{S}/\text{cm}$ the rest of the year. South Delta EC values are higher than at Vernalis because additional salinity from agricultural drainage enters south Delta channels downstream of Vernalis. Additional salt is added by the Stockton Wastewater Treatment Plant effluent discharged near the Stockton Deep Water Sea Channel.

¹ The estuarine entrapment zone, an important aquatic habitat region associated with high levels of biological productivity, is defined by the mean daily EC range of about 2 to 10 millisiemens per centimeter (mS/cm) (Arthur and Ball, 1980).

DWR and Reclamation are responsible for meeting water quality salinity objectives in the Delta pursuant to SWRCB water rights decision D-1641. DWR and Reclamation monitor EC at several Delta locations, and adjust Delta inflows and exports to the extent possible to help provide the necessary outflows to meet the salinity objectives for municipal and industrial, agricultural, and fish and wildlife uses. In 2005, the SWRCB issued a Cease and Desist Order to Reclamation and DWR requiring compliance with salinity objectives in the interior south Delta. DWR and Reclamation are meeting the requirements of the Order, which requires the agencies to maintain accurate EC data from the three south Delta compliance locations and to report any potential/actual violations. Releases from New Melones Reservoir are generally used by Reclamation to control the salinity of the San Joaquin River (as required under SWRCB D-1641), but there is a maximum specified volume of water reserved for this purpose.

Ammonia

Ammonia, specifically the unionized form, is toxic to fish, with salmonid species being most sensitive. Studies also suggest that Delta smelt may be particularly sensitive to ammonia, and that ammonia may limit primary productivity in the Delta. Algae growth is inhibited when nitrogen is in the form of ammonia rather than nitrate. Major sources of ammonia loading to the lower Sacramento River include agricultural discharges and wastewater treatment plant discharges. The effects of these discharges on the Delta ecosystem are not well understood, and additional investigations are planned to determine the importance of these potential impacts.

Pesticides

Diazinon and chlorpyrifos are man-made pesticides that can be acutely toxic to aquatic life, wildlife, and humans. The sources of the diazinon and chlorpyrifos found in the Delta are urban and agricultural applications. In the Central Valley, diazinon and chlorpyrifos are used to exterminate destructive pests and insects, and a fraction of urban and agricultural diazinon and chlorpyrifos applications can reach surface water during rainfall or irrigation events. Aquatic invertebrates appear to be the aquatic organisms most sensitive to chlorpyrifos and diazinon exposure (Giddings et al., 2000). A recent Basin Plan Amendment added numeric standards for diazinon and chlorpyrifos.

Dissolved Minerals

Dissolved minerals (chloride and bromide) concentrations are important in evaluating domestic water supply quality, and sodium concentration is important for both agricultural and domestic water quality. The ratio of chloride to EC (using units of milligrams per liter for chloride and $\mu\text{S}/\text{cm}$ for EC) can be used to distinguish between sources of water from different inflows (e.g., Sacramento River, San Joaquin River, and seawater) sampled at different Delta locations.

Trihalomethanes

DOC is one of the primary variables that influence the potential for the formation of THMs, which are formed during chlorination of Delta source water. EPA has established a maximum contaminant level for THMs in treated drinking water. A suspected carcinogenic risk from THMs has led some communities to revise their methods of disinfecting drinking water through alternatives to chlorination, such as ozonation or chloramines (although other potentially harmful disinfection byproducts may be formed during these processes).

Bromate is a disinfection byproduct associated with ozone treatment and is formed during ozonation in the presence of bromide ions. Bromide concentration is directly proportional to chloride concentration; therefore, a slight increase in bromate may occur if salinity is increased in a drinking water source. Minimizing DOC and salinity (i.e., bromide) concentrations in raw source water is a major water quality management goal.

The MWQI Program has documented that Delta exports contain relatively high concentrations of DOC. Agricultural drainage discharges containing natural decomposition products of peat soil and crop residues are considered dominant sources of DOC in Delta waters (DWR, 1994a). Also, the MWQI Program has determined that bromide ions in Delta water contribute significantly to the formation of THMs. Sources of bromide in Delta water are seawater intrusion, San Joaquin River inflow containing agricultural drainage, and possibly groundwater. The Delta agricultural drainage component of the MWQI Program has sampled discharge points of irrigation drainage water in the Delta since 1985. The salt content of irrigation drainage is greatest between October and March, as a result of the leaching of salts from Delta island soils between growing seasons.

Geology

The thick alluvial deposits of the Delta consist of Holocene flood basin deposits known as Dos Palos Alluvium. Underlying these alluvial sediments are Pleistocene, Pliocene/Miocene, Jurassic, and Mesozoic/Paleozoic formations. From youngest to oldest, these formations are older alluvium, fanglomerate deposits, Copper Hill Volcanics, Merced Falls Slate and Salt Springs Slate, Gopher Ridge Volcanics, and ultramafic rocks (Wagner et al., 1990). Delta paleosols represent a complex intermingling of coarse sand and gravel bedload deposits, sand- and silt-sized overbank deposits, and silt- and clay-sized backswamp deposits.

Historically, land subsidence has been a significant problem in the Delta. Land subsidence is a result of compaction of “peat” or highly organic soils and/or hydrocompaction. Land subsidence increases channel pressure on levees, increasing the probability of levee failure and associated flooding (DWR, 1993). Consequently, Delta levees are currently in need of continual maintenance.

The Delta is subject to seismic activity from several faults, primarily the San Andreas Fault system and Hayward Fault. Other faults, including the Healdsburg-Rogers Creek Fault, Maacama Fault, Coast Range Sierra Nevada

Boundary Zone, and Green Valley-Cordelia and Concord Faults also affect Delta seismicity, but to a lesser degree.

Flood Control

Until the 1850s, the Delta was primarily a tidal marsh that became a great inland lake during the flood season. Flooding of reclaimed Delta lands was a frequent result of levee erosion and overtopping during high-flow events.

Development of the Delta began in 1850 when the Federal Swamp Land Act conveyed ownership of all swamp and overflow land (including Delta marshes) from the federal government to the State of California. Proceeds from the state's sale of swampland were dedicated to reclaiming wetlands and converting them to agricultural land. The first reclamation projects began in 1869 and continued until 1913, when 1,100 miles of levees were completed.

Since reclamation, each of the Delta's 70 major islands or tracts has flooded at least once. About 100 failures have occurred since the early 1900s. Except for Big Break, Franks, Little Franks, and Little Holland Tracts and Little Mandeville, Lower Sherman, and Mildred Islands, flooded islands historically have been restored even when the cost of repairs exceeded the appraised value of the land. Two flooded Delta tracts—Franks Tract and Little Franks Tract—were submerged by levee breaks in 1937 and 1938. In 1937, the local Reclamation district spent \$100,000 to repair the levee and pump the water out. After the second break in 1938, the 3,500-acre area was left flooded and was eventually acquired by the state parks system as Franks Tract State Recreation Area. Since construction of the CVP and SWP, the frequency of levee failure attributable to overtopping has decreased. Flooding is generally restricted to inundation of individual islands or tracts resulting from levee instability or overtopping due to high tides and winds. Since 1950, the construction of upstream dams has provided the ability to detain flood flows, further reducing the threat of overtopping. Between 1950 and 1986, 60 percent of levee failures were attributable to mass instability, commonly caused by a combination of seepage and historical subsidence; and 40 percent of failures were attributable to overtopping.

The flood control facilities that currently protect the Delta include Delta levees, the Delta Cross Channel, and the Yolo Bypass. The Cross Channel gates are closed during high flows and floods on the Sacramento River to prevent water from spilling out of the Sacramento River into the Mokelumne River and flooding leveed and non-leveed lands. If storms hit central California while the river stages are lower on the Sacramento River, the gates can be opened to spill high flows out of the Mokelumne River system and reduce stages on the North and South Forks of the Mokelumne River. This transfers floodwater from the non-project levees of the Mokelumne River to the Sacramento River, which is protected by project levees.

Unlike the system of reservoirs and weirs that control the magnitude of flooding of rivers upstream of the Delta, the flood control system in the Delta (aside from

the DCC control gates) operates passively. However, the levee system does require maintenance, monitoring, and improvement, particularly during floods, to maximize the level of protection provided.

Sediment Transport

Flow into the Delta comes from two major rivers—the Sacramento River (80 percent of Delta inflow) and the San Joaquin River (10 percent of Delta inflow)—and smaller rivers such as the Mokelumne and Cosumnes. Sediment loads entering the Delta are dependent on the spatial and temporal distribution of inflow. The sediments being transported into the Delta by the Sacramento River include fine sands transported in the bed load and silts and clays transported in the suspended load. Coarser materials remain at points higher up in the basin. Sediment loads in the San Joaquin River are highest in early to mid-spring when the snowpack is melting. Sediments reaching the Delta from the south are mostly fine sands.

While the Delta is a complex combination of man-made and natural channels, it is subject to significant tidal influence. Tidal flows have a profound influence on the hydrodynamics of the system, thus affecting how sediments are transported and deposited within the Delta.

A majority of naturally eroded and transported solid particles settle out in reservoirs, while a percentage of fine solids, like silts and clays, are transported during water releases. Rather than settling-out in the alluvial plain, as occurred before the channels were constructed, most solids and fine solids currently remain within Delta channels (except in areas where water velocities are low). During wet-weather/high-flow periods, a high percentage of solids are re-suspended and transported downstream. Many factors affect the scour (and sediment) patterns, including the amounts of rainfall and runoff, dredging activities, and levee and channel stability.

Groundwater

The NoCDIS project has the potential to affect groundwater conditions in the Delta and in the service areas for CVP and SWP water supplies. Groundwater provides 31 percent of the total water supply for urban and agricultural uses in the Sacramento River hydrologic region, and 30 percent of demand in the San Joaquin River hydrologic region (DWR, 2003). Therefore, protection of groundwater resources is critical to ensure that future needs can continue to be met.

Throughout the Delta, there is a high level of interaction between surface water and groundwater, and changes in surface water levels can affect local groundwater elevations.

Historically, groundwater resources have been extensively developed to meet agricultural demands. Before development of the CVP, groundwater overdraft conditions occurred in portions of the San Joaquin Valley hydrologic region as a

result of reliance on groundwater, especially during drought years. The development of surface water supplies reduced reliance on groundwater and helped control the rapid rate of groundwater decline. However, the long-term, continued groundwater use has resulted in land subsidence throughout the region. Prior to the mid-1950s, the interaction of groundwater and surface water in the San Joaquin Valley resulted in a net gain to streams; however, under more recent conditions, a net loss from streams to the groundwater system has occurred as a result of groundwater decline from increased pumping.

Because surface water supplies are abundant in the Sacramento valley, the use of groundwater for agriculture primarily supplements the surface water supply. However, changing environmental laws and requirements have resulted in a shift to a greater reliance on groundwater, and conjunctive use of surface and groundwater supplies is occurring to a greater extent, particularly in drought years. Groundwater quality in the Sacramento River hydrologic region is generally excellent; however, there are areas with local groundwater problems. For example, water quality impairments occur where brackish to saline water near the surface mix with freshwater in the aquifer and degrade groundwater quality.

Hydrologically driven short-term salinity increases in the Sacramento-San Joaquin Delta are unavoidable. When freshwater flows decrease, higher salinity water can move into the Delta. While the extent of salinity intrusions is mitigated by freshwater releases during the summer and fall, the Delta is susceptible to salinity intrusions in the spring when upstream reservoirs capture snowmelt runoff and effectively remove water from Delta outflow.

In general, the largest sources of salts in the Delta are derived from agricultural activities that mobilize salts in soils or contain salts in imported water supply. Therefore, increases in Sacramento River salinity increase salinity problems in the south basin and for all Delta exporters because of larger salt loads in imported water supply. The contribution of CVP-imported salts to the San Joaquin River, decreased flows in the San Joaquin River due to CVP operations, and the concentration of salts in Delta channels due to altered flow regimes are well known and documented. Consequently, elevated groundwater salinity in the Central Valley is an increasing problem.

Salts added to surface water can have both short- and long-term effects on groundwater quality. The use of higher salinity surface water for irrigation results in subsequent salt buildup in deeper groundwater bodies (aquifers) and in shallow groundwater (near plant root-zone). High-salinity irrigation water results in the accumulation of dissolved mineral salts in waters and soils due to evaporation, transpiration, and mineral dissolution. In addition, high groundwater levels can affect crop production by inundating the root zone. Therefore, groundwater pumping is conducted to keep water levels below the root zone such that crop production is not compromised.

During the summer months, irrigation return flows are the primary source of recharge for the Central Valley's large aquifers. Irrigation seepage, agricultural return flows, and stormwater runoff are all pathways for contamination in areas

where groundwater aquifers underlie porous soils that receive heavy nutrient or chemical applications. Water quality constituents of concern related to groundwater in the Delta include nutrients, pesticides, salt, trace elements, organic carbon, and microorganisms.

With few new surface water storage projects under development, there is increasing reliance on groundwater, and conjunctive use of surface and groundwater supplies. By their very nature, conjunctive use projects can have an adverse effect on overall salinity. This is because pumped groundwater is generally of poorer quality than surface water supplies; therefore, pumped groundwater can contribute significant additional salt loads to surface waters when used as an irrigation or municipal supply (SWRCB, 2005).

Transportation/Navigation

Interstate 5 and Interstate 205 traverse the periphery of the Delta. Road access to more central Delta areas is provided by State Highways 4, 12, and 160, and by numerous county roads.

The Union Pacific and Burlington Northern and Santa Fe (BNSF) railroads maintain active railways in the Delta. However, only the BNSF railroad traverses the Delta lowlands and requires levees for protection. The other railways are on the periphery of the Delta. Rail lines in the Delta region are used for both passenger and freight services. The Union Pacific Railroad runs northwest-southeast and carries mainly freight traffic. The BNSF railroad provides passenger service between Stockton and Antioch and to cities beyond. Rail services using these lines include Amtrak and the Altamont Commuter Express. Amtrak provides services between Stockton and San Jose, and the San Joaquin route makes stops in Antioch. The Altamont Commuter Express provides direct commuter rail service to Silicon Valley (with stops in Stockton, Lathrop, Manteca, and Tracy).

The Delta is an important and unique regional recreation resource located in the center of the rapidly urbanizing areas of Rio Vista, West Sacramento, Sacramento, Elk Grove, Lodi, Stockton, Lathrop, Tracy, and numerous communities in eastern Contra Costa County. A California Department of Parks and Recreation survey of boaters and anglers conducted in 1997 indicated that approximately 50 percent of the recreationists in the Delta live within 50 miles of the Delta, and the average distance traveled one way was 70 to 75 miles. The Delta Boating Needs Assessment thus defines the Delta's primary market area as Alameda, Calaveras, Contra Costa, Marin, Napa, Sacramento, San Francisco, San Joaquin, San Mateo, Santa Clara, Santa Cruz, Solano, and Stanislaus Counties.

Most Delta waterways are public waterways navigable by recreational craft and smaller commercial vessels, including towing and salvage vessels, clamshell dredges, dredges used for levee maintenance and repair, and pile-driving vessels. Channels in the greater Delta waterways also serve commercial vessels. The Stockton Deep Water Ship Channel and the Sacramento Deep Water Ship

Channel serve deep draft oceangoing vessels at the inland Ports of Stockton and Sacramento. Approximately 5 million tons of cargo is handled annually by the two ports. The Port of Stockton, located on the Stockton Deep Water Ship Channel, is the second largest inland seaport on California's West Coast.

The Delta contains more than 1,000 miles of navigable waterways. Boating and fishing account for about 70 percent of Delta recreation use, and boaters and anglers spend more than \$810 million in and around the Delta annually. The Delta is also less restrictive than most other areas in terms of the types of water craft permitted, the number of boats (all classes) allowed on any given day, and the types of engine or fuel systems permitted.

Air Quality

Air quality is affected by various factors, including the locations of air pollutant sources, the amount of pollutants emitted, and meteorological and topographical conditions affecting pollutant dispersion. Atmospheric conditions, including wind speed, wind direction, and air temperature gradients, interact with the physical features of the landscape to determine the movement and dispersal of air pollutants.

The NoCDIS project is located within the Sacramento Valley Air Basin (SVAB) and the San Joaquin Valley Air Basin (SJVAB). The SVAB is bound on the west by the Coast Ranges, on the north by the Cascade Range, and on the east by the Sierra Nevadas. The Sacramento Metropolitan Air Quality Management District has jurisdiction over air quality issues within the Sacramento County portion of the SVAB. The SJVAB is defined by the Sierra Nevadas to the east, the Coast Ranges to the west, and the Tehachapi Mountains to the south. The San Joaquin Valley Air Pollution Control District has jurisdiction over air quality issues throughout the eight-county SJVAB.

Noise

The Delta is primarily agricultural land with few noise-sensitive land uses. The existing noise environment is governed primarily by vehicular traffic along Highway 4 and other roadways, occasional aircraft, and agricultural operations. Table 3-1 was included in the noise chapter of the 2000 CALFED Programmatic EIS/EIR, and can be used to generally characterize noise conditions in the Delta area.

TABLE 3-1
Population Density and Associated Ambient Noise Levels

Location	L _{dn} (A-Weighted Decibel)
Rural	
Undeveloped	35
Partially developed	40
Suburban	
Quiet	45
Normal	50
Urban	
Normal	55
Noisy	60
Very noisy	65

Fish

The Delta is home to several native fish species and desirable alien species (such as striped bass) that have declined precipitously and continue to decline, even to the verge of extinction. Central Valley steelhead, Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley fall- and late fall-run Chinook salmon, Delta smelt, green sturgeon, and longfin smelt are all native species of concern that occur in streams of the Central Valley and the Delta. The following is a general description of factors that influence the survival of fish species, followed by a description of the requirements of the previously mentioned species.

The availability of rearing habitat may limit the production of juveniles and subsequent adult abundance of some fish species. Fish species have different responses to water temperature depending on their physiological adaptations, and fish species at different life stages have different water temperature requirements (e.g., eggs and larval fish are most sensitive to warm water).

All fish species are entrained to varying degrees by the SWP and CVP export facilities and other diversions in the Delta and Central Valley Rivers. Fish entrainment and subsequent mortality is a function of the size and location of the diversion, the behavior of the fish, and other factors such as the presence of fish screens and predatory species. Low approach velocities are assumed to minimize stress and protect fish from entrainment.

In the Sacramento and San Joaquin Rivers Basins, industrial and municipal discharge and agricultural runoff introduce contaminants into rivers and streams that ultimately flow into the Delta. Organophosphate insecticides including diazinon, chlorpyrifos, and carbofuran are present throughout the Central Valley, and are dispersed in agricultural and urban runoff. Organophosphate pesticides

are toxic to invertebrates and, through bioaccumulation, may become toxic to some fish species, including Chinook salmon, steelhead, and Delta smelt.

Food availability and type also affect the survival of various fish species. Nonnative species both compete with natives for food, and prey on native species. In addition, flow affects the abundance of food in rivers, the Delta, and Suisun Bay, with higher flows generally resulting in a greater input of nutrients and higher productivity, which increases the availability of prey organisms for fish species. In addition, higher flow levels decrease salinity in the shallows of Suisun Bay, which benefits productivity.

Central Valley Steelhead

Steelhead have one of the most complex life histories of any salmonid species. Steelhead are anadromous, but some individuals may complete their life cycle within a given river reach. Freshwater residents typically are referred to as rainbow trout, while anadromous individuals are called steelhead (NMFS, 1996). The Delta and Sacramento, San Joaquin, Feather, Yuba, American, and Mokelumne Rivers provide a migration pathway between freshwater and ocean habitats for adult and juvenile steelhead. Historical records indicate adult steelhead enter the mainstem Sacramento River in July, peak in abundance in September and October, and continue migrating through February or March (McEwan and Jackson, 1994; Hallock, 1989). Unlike Pacific salmon, some steelhead may survive to spawn more than one time, returning to the ocean between spawning migrations.

Juvenile migration to the ocean generally occurs from December through August. Most Sacramento River steelhead migrate in spring and early summer (Reynolds et al., 1993). Sacramento River steelhead generally migrate as 1-year-olds at a length of 6 to 8 inches (15.2 to 20.3 cm) (Barnhart, 1986; Reynolds et al., 1993). Their presence in the Delta is primarily from December through May (The Bay Institute, 2007). Although steelhead have been collected in most months at the state and federal export facilities in the Delta, the peak numbers salvaged at these facilities occur in March and April in most years. After 2 to 3 years of ocean residence, adult steelhead return to their natal stream to spawn as 3- or 4-year-olds (NMFS, 1998).

Adult steelhead appear to be much more sensitive to thermal extremes than are juveniles (NMFS, 1996; McCullough, 1999), and successful adult migration and holding is assumed to deteriorate as water temperature warms between 52 and 70°F (11.1 and 21.1°C). Conditions supporting steelhead spawning and incubation are assumed to deteriorate as temperature warms between 52 and 59°F (11.1 and 15°C) (Myrick and Cech, 2001). Juvenile rearing success is assumed to deteriorate at water temperatures ranging from 63 to 77°F (17.2 to 25°C) (Raleigh et al., 1984; Myrick and Cech, 2001). Smolt transformation requires cooler temperatures ranging from 43 to 50°F (6.1 to 10°C). However, juvenile steelhead have been captured at Chipps Island in June and July at water temperatures exceeding 68°F (Nobriega and Cadrett, 2001).

Central Valley Spring-run Chinook Salmon, Central Valley Fall- and Late Fall-run Chinook Salmon, and Sacramento River Winter-run Chinook Salmon

Naturally spawning Chinook salmon are in decline, largely due to dams and diversions. The population of Central Valley fall-run Chinook salmon has been relatively stable in recent years, but the current run (2007-2008) is far below the population levels from prior years. The reasons for this drastic population decline are unknown. Winter-run Chinook have been listed as both a state and federal endangered species since 1994. Spring-run Chinook are also listed as both a state and federal threatened species.

The Delta and Sacramento, San Joaquin, Feather, Yuba, American, and Mokelumne Rivers provide a migration pathway between freshwater and ocean habitats for all runs of Chinook salmon. Migration habitat conditions include stream flows that provide suitable water velocities and depths that provide successful passage. Flows in the Sacramento, Feather, Yuba, American, and Mokelumne Rivers and in the Delta provides the necessary depth, velocity, and water temperature. Within the Delta, channel pathways affect migration of juvenile Chinook salmon, and juvenile Chinook salmon survival is lower for fish migrating through the central Delta (diverted into the Delta Cross Channel and Georgiana Slough) than for fish continuing down the Sacramento River (Newman and Rice, 1997). Similarly, juvenile Chinook salmon entering the Delta from the San Joaquin River appear to have higher survival if they remain in the San Joaquin River channel instead of moving into Old River and the south Delta (Brandes and McLain, 2001).

Rearing habitat for salmonids is defined by environmental conditions such as water temperature, DO, turbidity, substrate, water velocity, water depth, and cover (Jackson, 1992; Bjornn and Reiser, 1991; Healey, 1991). Chinook salmon also rear along the shallow vegetated edges of Delta channels (Grimaldo et al., 2000). Environmental conditions and interactions between individuals, predators, competitors, and food sources determine habitat quantity and quality (Bjornn and Reiser, 1991). High flow increases the area available to juvenile Chinook salmon because they rely on submerged terrestrial vegetation in the floodplain and at the channel edge; in addition, deeper inundation provides more overhead cover and protection from avian and terrestrial predators (Everest and Chapman cited in Jackson, 1992). Changes in flow affect juvenile Chinook salmon most, particularly in the riffles and shallow glides of broad, low-gradient rivers (Jackson, 1992).

Juvenile salmonid survival, growth, and vulnerability to disease are affected by water temperature. In addition, water temperature affects prey species abundance and predator occurrence and activity. Juvenile salmonids alter their behavior depending on water temperature, including movement to take advantage of local water temperature refugia (e.g., movement into stratified pools, shaded habitat, and subsurface flow) and to improve feeding efficiency (e.g., movement into riffles).

Salmonids in general have evolved under conditions in which water temperatures need to be relatively cool. Water temperature in Central Valley rivers frequently exceeds the tolerance of Chinook salmon and steelhead life stages. Based on a literature review, conditions supporting adult Chinook salmon migration are assumed to deteriorate as temperature warms between 54 and 70°F (12.2 and 21.1°C) (Hallock, 1970, as cited in McCullough, 1999). For juvenile Chinook salmon, survival is assumed to decline as temperature warms from 64 to 75°F (17.8 to 23.9°C) (Myrick and Cech, 2001; Rich, 1987). Relative to rearing, Chinook salmon require cooler temperatures to complete the parr-smolt transformation and to maximize their saltwater survival. Successful smolt transformation is assumed to deteriorate at temperatures ranging from 63 to 73°F (17.2 to 22.8°C) (Marine, 1997, cited in Myrick and Cech, 2001; Baker et al., 1995).

Cover, space, and food are necessary components for Chinook salmon-rearing habitat. Suitable habitat includes areas with instream and overhead cover in the form of cobbles, rocks, undercut banks, downed trees, and large, overhanging tree branches. The organic materials forming fish cover also provide sources of food in the form of both aquatic and terrestrial insects.

Juvenile Chinook salmon move downstream in response to many factors, including inherited behavior, habitat availability, flow, competition for space and food, and water temperature. The number of juveniles that move and the timing of movement are highly variable. Storm events and the resulting high flows appear to trigger movement of substantial numbers of juvenile Chinook salmon to downstream habitats. In general, juvenile abundance in the Delta appears to be higher in response to increased flow (USFWS, 1993). Juvenile Chinook salmon are entrained in all months, but are primarily entrained from November through June when juveniles are migrating downstream.

Historical records indicate that adult spring-run Chinook salmon enter the mainstem Sacramento River in March and continue to their spawning streams where they hold until September. Spawning occurs in gravel beds in late August through October, and emergence begins in December. Young-of-year juveniles migrate downstream between February and June, and yearling juveniles migrate from October to March, with peak migration in November (Cramer and Associates, 1996).

Adult fall-run and late fall-run Chinook salmon enter the Sacramento and San Joaquin Rivers systems from July through February and spawn from October through March. Juveniles migrate downstream from October to June.

Adult winter-run Chinook salmon migrate through the Delta into the Sacramento River from December through July. Juvenile winter-run Chinook salmon rear and migrate in the Sacramento River from July through March (Hallock and Fisher, 1985; Smith pers. comm.) and migrate downstream (above Red Bluff Diversion Dam) from August through October/November. However, juveniles have been observed in the Delta between October and December during high Sacramento

River discharge in response to fall and early winter storms. Juveniles migrate through the Delta to the ocean from December through May (Stevens, 1989).

Studies at Clifton Court Forebay estimated predator-related mortality of hatchery-reared fall-run Chinook salmon from about 60 percent to more than 95 percent. Although the predation contribution to mortality is uncertain, the estimated mortality suggests that striped bass and other predatory fish, primarily nonnative, pose a threat to juvenile Chinook salmon moving downstream, especially where the stream channel has been altered from natural conditions (DWR, 1995). Turbulence after passing over dams and other structures may disorient juvenile Chinook salmon, thereby increasing their vulnerability to predators.

Delta Smelt

Abundance of Delta smelt, listed as a state and federal threatened species in 1993, generally increased throughout much of the 1990s. Delta smelt spawn in freshwater at low tide on aquatic plants, submerged and inshore plants, and over sandy and hard bottom substrates of sloughs and shallow edges of channels in the upper Delta and Sacramento River above Rio Vista (Wang, 1986; Moyle, 2002). Spawning habitat area has not been identified as a factor affecting Delta smelt abundance (USFWS, 1996), but little is known about specific spawning areas and requirements within the Delta. Larval and early juvenile Delta smelt are transported by currents that flow downstream into the upper end of the mixing zone of the estuary where incoming saltwater mixes with outflowing freshwater (Moyle et al., 1992). Therefore, reduced flow may adversely affect the transport of larvae and juveniles to rearing habitat.

Estuarine rearing habitat for juvenile and adult Delta smelt is typically found in the waters of the lower Delta and Suisun Bay where salinity is between 2 and 7 parts per thousand (ppt). Delta smelt tolerate 0 to 19 ppt salinity. They typically occupy open shallow waters, but also occur in the main channel in the region where freshwater and brackish water mix. USFWS (1996) has indicated that loss of rearing habitat area would adversely affect the abundance of larval and juvenile Delta smelt. During years of average and high outflow, Delta smelt may concentrate anywhere from the Sacramento River around Decker Island to Suisun Bay (Moyle, 2002). However, this geographic distribution may not always be a function of outflow and the 2 ppt isohaline position, and may only account for about 25 percent of the annual variation in abundance (DWR, 1994b).

Delta smelt are adapted to water temperature conditions in the Delta and can tolerate warmer temperatures as compared to other native Delta species. Delta smelt may spawn at temperatures as high as 72°F (22.2°C) (USFWS, 1996), and can rear and migrate at temperatures as warm as 82°F (Swanson and Cech, 1995). Rearing habitat for larval and early juvenile Delta smelt encompasses the lower reaches of the Sacramento River below Isleton and the San Joaquin River below Mossdale.

Adult Delta smelt begin spawning migration into the upper Delta beginning in December/January, and migration may continue over several months. Spawning occurs between January and July, with peak spawning during April through mid-May (Moyle, 2002). Spawning occurs along the channel edges in the upper Delta, including the Sacramento River above Rio Vista, Cache Slough, Lindsey Slough, and Barker Slough. Spawning has been observed in the Sacramento River up to Garcia Bend during drought conditions, possibly attributable to adult movement farther inland in response to saltwater intrusion (Wang and Brown, 1993). Eggs are broadcast over the bottom, where they attach to firm substrate, woody material, and vegetation. As they develop, larvae and juveniles gradually move downstream toward rearing habitat in the estuarine mixing zone (Wang, 1986).

The CVP and SWP fish facilities indicate entrainment of adult Delta smelt during spawning migration from December through April (DWR and Reclamation, 1994). Juveniles are entrained at the export facilities primarily from April through June. Predators such as striped bass, largemouth bass, and catfish also prey on Delta smelt (USFWS, 1996). However, the extent that these predators may affect Delta smelt populations is unknown. Species such as threadfin shad and wakasagi may affect Delta smelt survival through competition for food. Introduction of nonnative food organisms may also have an effect on Delta smelt and other species survival. Nonnative zooplankton species are more difficult for small smelt to capture, increasing the likelihood of larval starvation (Moyle, 2002). In addition, an invasion of *Corbula* clam may be impacting primary production and food availability. In shallow water, *Corbula amurensis* is capable of filtering the entire water column almost 13 times per day. At this rate of filtration, there are very few planktonic organisms left in the water column for larger animals to feed upon. Also, *Corbula* clam accumulates selenium at a high rate, and the fish that commonly feed on the clam are therefore ingesting selenium at levels that may impact reproductive success (San Francisco Estuary Institute, 2005).

Longfin Smelt

Longfin smelt populations have declined precipitously in the Delta Sacramento-San Joaquin Estuary where they were once one of the most abundant fish (Moyle et al., 1995). Because of their severe decline in abundance, the Natural Heritage Institute petitioned the USFWS in 1992 to list this species as endangered; that petition was denied in 1993. However, the California Fish and Game Commission accepted a petition for the listing of longfin smelt as a candidate species under the California ESA effective February 19, 2008. Moyle et al. (1995) states that the primary cause for the decline in abundance of longfin smelt is the reduction in outflows as a result of water exports in the Delta. Additional factors attributed to the decline of this species includes entrainment at the CVP and SWP export facilities, climatic variations, toxic substances, predation by striped bass in the Delta, introduced species, and loss or replacement of food sources for longfin smelt.

Adult and juvenile longfin smelt are pelagic (occupy the middle or bottom of the water column) in brackish portions of the estuary with larval stages occupying the near-surface areas within the water column. Their prey base has declined markedly in the Delta in recent years (The Bay Institute, 2007). Spawning occurs at water temperatures ranging from 7.0 to 14.5°C in fresh to slightly brackish waters (The Bay Institute, 2007). A strong positive correlation exists between winter and spring Delta outflow and longfin smelt abundance the following year, as well as juvenile survival in the estuary and Delta outflow (Stevens and Miller, 1983, as cited by Moyle et al., 1995). Adults occur in the open waters of the estuary at salinities ranging from fresh to fully seawater and, in most years, are found primarily in Suisun, San Pablo, and San Francisco Bays. Longfin smelt have a 2-year life cycle, although a small fraction of individuals may spawn as 1- or 3-year-old fish (The Bay Institute, 2007). Most spawning occurs between January and March, and larval metamorphosis into juveniles occurs roughly 30 to 60 days after hatching, depending on water temperatures. Based on their distribution patterns during the spawning season, the main spawning area for the San Francisco Bay-Delta Estuary longfin smelt appears to be downstream of Rio Vista on the Sacramento River (The Bay Institute, 2007).

Green Sturgeon

San Francisco Bay and its associated river systems contain the southernmost reproductive green sturgeon population. The species was first described here by Ayres (1854). Green sturgeon juveniles are found throughout the Delta and San Francisco Bay, mostly in small numbers. However, green sturgeon juveniles can sometimes number as many as 100, as indicated by fish taken in trammel net sampling and small boat trawls, presence in striped bass sampling, and entrainment by water export facilities.

Green sturgeon adults and juveniles occur throughout the upper Sacramento River, based on observations incidental to winter-run Chinook monitoring at the Red Bluff Diversion Dam. Green sturgeon spawning occurs predominantly in the upper Sacramento River. There is no documentation of green sturgeon spawning in the San Joaquin River, however, spawning likely occurred before construction of large-scale hydropower and irrigation development. Young green sturgeon have been taken occasionally in the Santa Clara Shoal area in the San Joaquin Delta, but these fish may have originated somewhere else.

North American green sturgeon were listed as a threatened species in 2006. Green sturgeon populations in the southern portion of their range (including the Delta) face smaller population size, the influence of toxic material and exotic species, potentially lethal temperature limits, and entrainment by water projects (although entrainment numbers have decreased dramatically since 1985). Larval green sturgeon have been shown to have lethal temperature limits near the summer temperatures in the Sacramento River, and spawning habitat may have been lost behind dams and water diversions throughout the Central Valley.

Wildlife

Natural land cover types present in the Delta include tidal perennial aquatic habitat (deepwater, shallow aquatic, and unvegetated intertidal areas within sloughs and channels), tidal freshwater emergent marsh, riparian woodland, riparian scrub, and ruderal vegetation.

- Tidal freshwater emergent marsh (tule and cattail tidal emergent wetland) includes all or portions of tidal and Delta sloughs, in-channel islands, and shoal habitats. Tidal emergent wetland occurs along all channels and most in-channel islands, and provides important wildlife habitat functions. Tidal emergent marsh occurring on or adjacent to in-channel islands provides foraging, nesting, and cover habitat for songbirds, birds, waterfowl, reptiles, and amphibians.
- Riparian woodlands occur throughout the Delta and provide important functions and values for wildlife. Riparian woodlands provide overstory vegetation that serves as nesting, roosting, and foraging habitat for various raptors and other bird species, including resident, migratory, and wintering songbirds. Riparian woodlands also provide habitat for several species of mammals, reptiles, and amphibians.
- Riparian scrub occurs throughout the Delta and includes riparian scrub, willow scrub, and stands of giant reed. Riparian scrub provides habitat functions and values for wildlife similar to riparian woodland, but without the overstory component.
- Ruderal vegetation is dominated by herbaceous, nonnative, weedy species, and generally occurs in disturbed upland areas, on levee slopes, and on the edges of agricultural fields and roads. Ruderal vegetation provides nesting and foraging habitat for several species of resident and wintering songbirds and several aquatic wildlife species.

Vegetation

Historically, the Delta consisted of a mosaic of tidal marshland dominated by bulrushes with a few low natural levees that supported woody riparian vegetation, grassland, and upland shrubs (Thompson, 1957). In the mid-1800s, levee construction increased, and marshland was drained to provide land for irrigated agriculture. By 1900, about one-half of the Delta's historical wetland areas had been diked and drained, and extensive reclamation continued through the 1940s. Today, the Delta is dominated by agricultural land. Some small, natural islands remain, as do some in-channel islands that are remnants of dredging and levee construction. In-channel islands provide valuable habitat that is relatively isolated from human disturbance and land-based predators, and most occurrences of special-status species occur on in-channel islands with no levees.

Levees in the Delta typically have waterside slopes that are rock-lined or are dominated by ruderal vegetation. Levees are actively maintained to control woody vegetation that could destabilize the levee structure and, as a result, there

is little or no native woody vegetation on Delta levees. Delta islands that are actively farmed contain little or no natural vegetation. Most of the Delta's remaining undisturbed native land cover types occur on in-channel islands or in small isolated patches along the waterside of the levees.

Typical land cover types in the Delta include tidal perennial aquatic habitat, tule and cattail tidal emergent wetland, cottonwood-willow woodland vegetation, valley oak riparian woodland, riparian scrub, willow scrub, and giant reed (*Arundo donax*).

Land Use

The NoCDIS project area is located within Sacramento, San Joaquin, and Contra Costa Counties. The County of Sacramento General Plan identifies the Delta's islands, waterways, and wetlands as a major open space area. The County attempts to direct urban growth to the metropolitan area to: discourage urban growth in outlying communities, protect agricultural lands, maintain natural resources, minimize infrastructure demand, reduce traffic and air quality impacts, preserve groundwater supplies, maintain job/housing balance, and prevent rural communities from becoming "bedroom communities." Growth is limited to varying degrees by sewage treatment capacity, flood constraints, and water quality impacts. Expansion of urban uses in rural areas is limited to established Delta communities that support the agriculturally and recreationally based economies of the Delta. The Delta Community Area Plan is incorporated by reference into the General Plan's Community Planning Element.

The 1992 San Joaquin County General Plan incorporates policies developed by the Delta Protection Commission under the Delta Protection Act. The Community Development Section of the General Plan addresses protection of open space and natural resources, including agricultural lands.

The Delta is located outside of the urban limit line adopted by Contra Costa County because of flood hazards, soil subsidence, lack of infrastructure, and lack of services. Areas to the north and east (including Delta islands and nearby tracts) are designated in the General Plan as "Delta Recreation and Resources." The designation recognizes location in the 100-year floodplain; limited public services; and the value of these areas for agriculture, wildlife habitat, and low-intensity recreation (Delta Protection Commission, 1995; 1997).

Socioeconomics

Population is growing in the Delta area because of a growing and diversifying economy, lower housing costs compared to the western San Francisco Bay Area, and an overall growth trend in the Central Valley. The areas growing the fastest are in the central and eastern sections of Alameda and Contra Costa Counties and western San Joaquin County (e.g., Tracy). Population growth in Contra Costa County is concentrated in the urban western half of the County.

The employment rate in the three-county area is fairly robust, and technology firms are moving into the region to fill market niches and take advantage of affordable rents. The unemployment rate in San Joaquin County is a little higher than in Alameda and Contra Costa Counties, but this is a reflection of seasonal changes in agricultural employment. Overall, all three counties are expecting job growth.

Services, government, retail trade, and agriculture are San Joaquin County's three largest industries (California Employment Development Department, 2002a; 2002b; 2002c). The services industry dominates the job base in Contra Costa County, and growth is expected to be concentrated in business, health services, manufacturing, and retail trade. Employment in Alameda County is currently based on the services, business, manufacturing, wholesale and retail businesses, and trade.

Public Services

The following categories of public services are relevant to the evaluation of the NoCDIS project:

- **Electricity.** Numerous power transmission lines of up to 500 kilovolts cross Delta islands and waterways; more are being planned, such as the California-Oregon transmission project. The Western Area Power Administration and Pacific Gas and Electric Company operate and maintain high-voltage transmission lines.
- **Natural Gas.** Natural gas was first discovered in the Delta in 1935. Today, the Delta serves as an important natural gas source and an underground gas storage area. Chevron Corporation operates and maintains several underground gas pipelines that transport natural gas and oil through the area.
- **Water Supply and Distribution.** Water supply and distribution are provided by a wide range of systems that serve statewide, regional, and individual needs. These range from large-scale elements of the SWP and CVP to the pumps and wells serving individual agricultural and residential uses.
- **Stormwater Drainage.** Delta areas are generally located in unmanaged stormwater drainage areas. Delta agricultural areas are typically drained by overland flow into man-made ditches, natural drainage swales, and watercourses that discharge into Delta waterways.
- **Wastewater.** Municipal and industrial wastewater is typically transported to a treatment facility where it is treated, and the treated effluent is discharged into a receiving water body. Wastewater is also handled by sanitary sewer systems and individual septic systems.
- **Solid Waste Disposal.** Solid waste in the Delta is transported to several landfills, depending on the area and/or county in which the waste was generated.

- **Communications.** AT&T, Inc. and a network of alternative telephone companies, cellular communication companies, and cable companies serve the Delta region. Communication lines are typically aligned parallel to the roadways, and then traverse the roadways to supply individual service units. Cable markers indicate underground cabling.
- **Police, Fire, and Ambulance Services.** Police and fire protection and ambulance services in the Delta are provided by various agencies in Sacramento, San Joaquin, and Contra Costa Counties, as well as by the California Highway Patrol.

Recreation

Recreation use of the Delta has increased substantially since the mid-1950s. Recreational use in the late 1950s and early 1960s was estimated at 2.5 million visitor days. By the late 1970s, recreation use in the Delta was estimated to range from 7 to 12 million visitor days. Current use levels are about 10 million visitor days, based on 1985 estimates expanded to account for population growth in the region. Based on recreation surveys conducted in 1996 for the Delta Protection Commission, the potential use level could be upward of 40 million visitor days.

The Delta is conveniently located near several large population centers, and serves the growing urban population in the Sacramento metropolitan area, the San Francisco Bay area, and the Stockton/Modesto/Tracy region. A state survey of boaters and anglers conducted in 1997 for the Delta Protection Commission indicated that approximately 50 percent of Delta recreationists live within 50 miles of the Delta, and the average distance traveled one way was 70 to 75 miles. In addition, the survey results indicated that a majority of visitors (50 to 60 percent) stay in the Delta 1 day or less. Approximately 35 percent stay 2 to 4 days, and approximately 11 percent stay 5 days or longer. The peak recreation period occurs from May through September. Use from March to September accounts for an estimated 75 percent of total annual use. According to the 1997 survey report, most boating use occurred between 8:00 a.m. and 4:00 p.m., and most use was by boaters during June, July, and August.

Most of the navigable waterways in the Delta are public, and most of the land is private. This lack of public lands limits the use of the Delta for recreation, causing concentration of use in a few areas where marinas and other facilities provide recreational opportunities and access to Delta waterways. Few public parks are located in the Delta, and some of the recreation areas are accessible only by boat, which also limits access to the Delta for some recreationists.

Recreation use in the Delta is primarily water-oriented. Almost every type of recreation boating activity can be found in Delta waterways. Activities include waterskiing, fishing, boating, sightseeing, camping, and picnicking. Fishing and boating are the most popular activities; together they comprise approximately 70 percent of total use. Boating accounts for approximately 17 percent of all visits, followed by fishing, relaxing, sightseeing, and camping.

Boating opportunities in the Delta have increased over the years and include houseboating, sailing, waterskiing, windsurfing, fishing, and other pleasure boating. Commercial boating excursions in the Delta are rare and are mainly limited to the Stockton Deepwater Ship Channel; however, individuals and groups often rent small fishing boats and houseboats.

Popular access points for boating, waterskiing, and personal watercrafting include: Windmill Cove near State Route 4; King Island, Paradise Points, Herman and Helen's Marina near Eight Mile Road; Tower Park near State Route 12; and River's End Marina and RV Park near the City of Tracy. Houseboating is concentrated along Eight Mile Road. Windsurfing typically occurs along State Route 160 between Sherman Island and Rio Vista, and at Windy Cove. The limited number of boating access points in the Delta and the lack of readily available rentals for ski boats and personal watercraft continue to be issues for recreational users.

Sport fishing in the Delta is a year-round activity and includes bank fishing and the use of private vessels and commercial passenger vessels. Important sport fish in the Delta include striped bass, white sturgeon, Chinook salmon, and American shad.

Much of the open space in the Delta is used for public parks and wildlife refuges. Approximately 23 public recreation facilities are located in the Delta. Three state agencies maintain five recreation areas, and the remaining recreation areas are operated by county and city agencies.

Hunting continues on private lands, in public areas, on waterways, and on various small Delta islands. Popular hunting areas include Sherman Island Wildlife Area, Twitchell Island, Franks Tract State Recreation Area, and Clifton Court Forebay.

Marinas account for most recreational facility types in the Delta. The majority of the 1997 survey respondents (83 percent) indicated that Delta marinas were either adequate or more than adequate, and the majority of respondents indicated that launch ramps and fuel docks were adequate or more than adequate. Respondents also thought that most types of other facilities were either adequate or more than adequate. Approximately 60 percent of respondents indicated that restrooms were either somewhat inadequate or very inadequate. Most respondents (67 percent) indicated that swimming beaches were either inadequate or very inadequate, and 59 percent of the survey respondents indicated that fishing piers were either somewhat inadequate or very inadequate.

Sightseeing was identified in the 1997 survey report as the most common activity, followed by boating and wildlife viewing, and windsurfing. Walking for pleasure ranked the highest in terms of average annual recreation days, followed by wildlife viewing, swimming, and attending special events. Tent camping and picnicking had the highest number of participants per group, followed by boating.

Visual

The Delta is a relatively flat and expansive area that occupies 1,100 square miles at the confluence of the Sacramento and San Joaquin Rivers. The Delta region can be described as two separate geographic and visual areas—lowlands and uplands. The lowlands range in elevation from below sea level to about 10 feet above mean sea level and have a generally flat topography. The uplands rise from around 10 to 100 feet above mean sea level in a gently sloping alluvial plain, forming a transition between the Delta lowlands and the inland hills of the Mount Hamilton, Altamont, and Diablo Ranges. The upland plain and the lowlands are distinguishable from one another by differences in vegetation, landform, waterforms, and development patterns. State Routes 4 and 160 are designated scenic highways in the region, although it is not possible to view Delta waterways from many sections of State Route 4 (CALFED Bay-Delta Program, 2000).

As an agricultural region, the Delta is largely altered from its natural state. Many of the Delta's constructed channels have noticeably visible differences from natural water bodies. Features such as diversion structures; regular, evenly sloped, and riprapped banks; and uniform, often straight, courses distinguish many of the dredged waterways. In some instances, slight differences in line and scale, instead of unnatural structures, are what set natural and altered channels apart, making the distinction less noticeable. Vegetation growth along the banks of watercourses created during reclamation helps them blend visually with natural channels. From a near viewpoint, rural residential and agricultural uses separate the Delta into orderly, cultivated rows and grids. Although the imprint of humans upon the landscape is obvious, the lack of permanent structures allows the area to remain a more natural setting, especially when viewed from a distance.

Public Health

Ecosystem restoration and management of the Bay-Delta ecosystem are complicated by mercury contamination from historic mining sites and historically contaminated waterways in the Sacramento and San Joaquin Rivers watersheds. Contaminated sites include the Sacramento and San Joaquin Rivers, the Delta, and San Francisco Bay. The Sacramento River watershed was a site of intensive historic mining for gold and mercury, and remains a primary source of mercury. Mercury contamination can impact downstream environments for decades to centuries after mining operations cease.

Although mercury often resides in forms that are not hazardous, it can be transformed through natural processes into a highly toxic form called "methylmercury," which readily accumulates in biota and can biomagnify or work its way up the food chain. The largest contributors of methylmercury in the environment appear to be sulfate-reducing bacteria, which occupy the anoxic sediment just below the sediment-water interface in water bodies and salt marshes.

Disturbance of mercury-contaminated sediments that were previously sequestered and therefore biologically unavailable has the potential to release mercury bound

to sediments and sulfides back into the environment. In addition, oxidizing conditions that occur during the placement of dredge materials for restoration purposes can cause mercury and sediments to be released into overlying waters. Once released, mercury cations become biologically available to mercury-methylating bacteria. The resulting concentration of methylmercury is dependent on numerous variables including salinity, pH, vegetation, sulfur concentration, DOC, oxidation and reduction, and seasonal variations.

Concerns about mercury pollution stem largely from the potential adverse effects of dietary exposure to methylmercury. Documented consequences of methylmercury pollution include: (1) direct adverse effects on the health and fitness of fish, wildlife, and humans; (2) contamination of fishery resources that diminishes their nutritional, cultural, socioeconomic, and recreational benefits; and (3) socio-cultural damage to indigenous peoples who fish for subsistence (Mahaffey, 2000; NRC Committee on Toxicological Effects of Methylmercury, 2000; Wheatley and Wheatley, 2000; Clarkson, 2002; Wiener et al., 2003). Nearly all of the mercury in fish is methylmercury (Grieb et al., 1990; Bloom, 1992), and consumption of fish is the primary modern pathway of methylmercury exposure in humans (NRC Committee on the Toxicological Effects of Methylmercury, 2000; Mahaffey, 2000; Clarkson, 2002). Dietary exposure to methylmercury can be substantial for predatory fish and wildlife at the top of aquatic food webs (Wiener et al., 2003), and recent studies suggest that the reproductive success of some nesting aquatic birds is being adversely affected by methylmercury exposure in the Bay-Delta ecosystem (Hoffman et al., 1998; Heinz, 2003; Schwarzbach and Adelsbach, 2003).

Flooding of vegetated wetlands or uplands and fluctuating water levels during tidal cycles may also stimulate microbial methylation of inorganic mercury (Hecky et al., 1991; Hall et al., 1998; Paterson et al., 1998; Bodaly and Fudge, 1999; Hall et al. in press).²

Cultural

Little is known about human occupation in the lower Sacramento Valley prior to 4500 Before Present (B.P.). Because of rapid alluvial and colluvial deposition in the valley over the past 10,000 years, ancient cultural deposits are deeply buried in many areas. The earliest evidence of widespread occupation of the lower Sacramento Valley/Delta region comes from several sites assigned to the Windmill Pattern (previously, Early Horizon), circa 4500 to 2500 B.P. (Ragir, 1972).

The succeeding Berkeley Pattern (formerly the Middle Horizon) dates from circa 2500 to 1500 B.P. in the Central Valley. Berkeley Pattern sites are greater in number and more widely distributed than Windmill sites and are characterized by deep midden deposits, suggesting intensified occupation and a broadened subsistence base.

² <http://calwater.ca.gov/science/pdf/MercuryStrategyFinalReport.pdf>.

The late prehistoric period (circa 1500 to 100 B.P., formerly the Late Horizon) is characterized by the Augustine Pattern (Fredrickson, 1973). The Augustine Pattern represents the peak cultural development of the prehistoric period in the lower Sacramento Valley and Delta regions, and is characterized by intensified hunting, fishing, and gathering subsistence strategies; large, dense populations; highly developed trade networks; elaborate ceremonial and mortuary practices; and social stratification.

The aboriginal inhabitants of the area in which the Area of Potential Effect is located are known as the Northern Valley Yokuts. Yokuts is a term applied to a large and diverse number of peoples inhabiting the San Joaquin Valley and Sierra Nevada foothills of central California. The Yokuts cultures include three primary divisions, corresponding to gross environmental zones: the Southern Valley Yokuts, the Foothill Yokuts, and the Northern Valley Yokuts (Kroeber, 1976; Silverstein, 1978). The Yokuts were seasonally mobile hunter-gathers with semi-permanent villages. Seasonal movements to temporary camps would occur to exploit food resources in other environmental zones. The Yokuts first came into contact with Europeans when Spanish explorers visited the area in the late 1700s, followed by expeditions to recover Indians who had escaped from the missions. The Northern Valley Yokuts were far more affected by missions than were the other groups. The loss of individuals to the missions, the influence of runaway neophytes, various epidemics in the 1800s, and the arrival of settlers and miners inflicted major depredations on the Yokuts peoples and their culture (Wallace, 1978).

In general, European settlers in Alta California ignored the Central Valley until the mid-19th century. Following the Gold Rush, settlement in the Delta region increased dramatically, largely as a result of the passage of the Swamp and Overflow Act in 1850, which transferred swamplands from the U.S. Government into the control of the State of California. As a result of this act, approximately 500,000 acres of newly acquired California swampland located in the Delta (and including the project area) were sold to private citizens (CALFED Bay-Delta Program, 1996; Thompson, 1957).

Locke is a “legacy town” along the Sacramento River close to the DCC with a historic Chinese immigrant and Chinese-American community. Constructed in 1915, Locke was home to Chinese farmhands whose immigrant predecessors helped build the railroads and the Sacramento Delta levees that helped turn central California into a farming paradise. Following passage of the Swamp and Overflow Act of 1861, between 3,000 to 4,000 Chinese laborers came to the Delta under contract to American developers to build hundreds of miles of levees. Their task was arduous, requiring them to work in waist-deep water in an area in which malaria was still endemic. They cut drainage ditches, built floodgates, and slowly reclaimed a total of 88,000 acres of levees from Delta marshlands between 1860 and 1880.

The Delta’s Chinese population was made up of two separate groups that had emigrated from neighboring districts in the Guangdong Province in southeastern

China. One group came from Sze Yap and the other from the Chungshan District. Once the land became fit for agriculture, the Chinese remained in the Delta to become farm workers and tenant farmers. Under the terms of California's 1913 Alien Land Act, the Chinese were not allowed to own land. The law was not declared unconstitutional until 1952. Locke is the only rural Chinese village remaining in the whole of America and the only area in North America that can claim a continuous Chinese presence for over 125 years.

By the turn of the 20th century, transportation improved in the area when officials constructed roads on the tops of levees. Before this construction, roadways were virtually non-existent, and most local travel was by schooners or barges. Southern Pacific Railroad and Western Pacific Railroad also constructed alignments in the vicinity of the project area, which not only connected the Delta to populated centers such as Sacramento and San Francisco, but also encouraged the movement of agricultural products from the Delta to outlying markets (Thomas Brothers, 1920).

Environmental Justice

The Delta is located in San Joaquin and Contra Costa Counties. Of the total local area 2000 population, San Joaquin and Contra Costa Counties have minority percentages of 35.8 percent and 29.5 percent, respectively. For the State of California, 35.7 percent is considered to be of a minority race. For both San Joaquin County and the State of California, the largest percentage minority category within the Study area was "some other race," which included approximately 16.3 percent of the total population for both the county and the state. The "some other race" category includes all responses not included in White, Black or African American, American Indian and Alaska Native, Asian, and Native Hawaiian and Other Pacific Islander race categories (U.S. Census Bureau, 2003a). Hispanic/Latino is believed to constitute the majority of the "some other race" category.³ San Joaquin County had the highest percentage of Hispanic origin population at 30.5 percent. Contra Costa County had a 17.7 percent Hispanic origin population. For Contra Costa County, the largest minority population was categorized as Asian at 11.0 percent.

In 1999, 13 percent of households within San Joaquin County were determined to have an income below the poverty level. Contra Costa County had a lower percentage with 5.4 percent of its households having incomes below the poverty level. The State of California had 10.6 percent of households below the poverty level during the same period (U.S. Census Bureau, 2000).

³ Hispanic is considered an origin not a race by the U.S. Census Bureau. An origin can be viewed as the heritage, nationality group, lineage, or country of birth of the person or the person's parents or ancestors before their arrival in the United States (U.S. Census Bureau, 2000). People who identify their origin as Spanish, Hispanic, or Latino may be of any race. Therefore, those who are counted as Hispanic are also counted under one or more race categories.

Indian Trust Assets

Indian Trust Assets are legal interests in assets held in trust by the federal government for Indian Tribes or individual Indians. The trust relationship usually stems from a treaty, executive order, or act of Congress. Indian Trust Assets are anything that holds monetary value, which can include real property, physical assets, or intangible property rights. Examples of Trust Assets are lands, minerals, hunting and fishing rights, and water rights.

The nearest ITA to the project area, in the north of Delta area, is the Colusa Rancheria, which lies adjacent to the Sacramento River approximately 90 air miles north of the project area. In the north of Delta area, the Hoopa Valley Tribe has fishing rights on the Trinity River. The Hoopa Valley Indian Reservation was established along the Trinity River in the late 1800s. Historically, Trinity River fisheries provided the primary dietary staple and also supported commercial and subsistence fishing for Indians in the area. The fisheries also played a significant role in the Tribes' religious beliefs (U.S. Department of the Interior, 2000; Jones & Stokes, 2005).

Future Without-Project Conditions

Identification of the magnitude of potential impacts associated with the NoCDIS project is based not only on existing conditions, but also on an estimate of how these conditions could reasonably be expected to change in the future. This future without-project conditions section represents the likely future conditions in the Study area if the NoCDIS project is not implemented. Future without-project conditions will be used to assess and discuss environmental effects in compliance with the CEQA and NEPA.

Physical Environment

Basic physical conditions in the Study area are expected to remain relatively unchanged in the future, as no changes to area topography, geology, or soils are foreseen. However, there is growing concern that the region's hydrology will be altered by global climate change. Global climate change could decrease snowpack in the Sierras, which would affect the amount and timing of Delta exports. A 2006 California Climate Change Center report estimates that, under a low emissions global climate change scenario, California's temperatures would increase 3 to 5.5°F in the next 30 years. This would result in a 30 to 60 percent loss in Sierra snowpack, 6 to 14 inches of sea level rise, and up to 1.5 times more critically dry years. However, the uncertainties in assessing potential future impacts of climate change are many and comprise both physical processes and institutional changes responding to the physical changes. Governments could enact laws that change the way the Delta is operated in response to climate change predictions regarding sea level rise. Governments may also enact laws to curb greenhouse gas emissions or promote other mitigation measures.

Catastrophes, such as a major flood or earthquake, could cause levee failure or damage to the SWP/CVP export facilities, which could decrease or potentially stop water exports from the Delta. A 2003 USGS study concludes that there is a 62 percent probability of at least one magnitude 6.7 or greater quake striking the San Francisco Bay Region before 2032.

Changing environmental and Delta water quality regulations could decrease water supplies and reliability for Delta water contractors, including agricultural contractors in the southern Central Valley. With less-reliable surface water supplies, contractors would rely more on groundwater to meet water demands. This type of groundwater pumping could potentially exceed the safe yield of the basin and create overdraft conditions resulting in land subsidence and/or seawater intrusion.

With California's population projected to grow to nearly 46 million by the year 2020, demand on groundwater will increase significantly. Groundwater pumping will continue to increase in response to growing urban and agricultural demands. In many basins, the ability to use groundwater will be affected by overdraft and water quality. Over the long term, groundwater extraction cannot be relied on to meet the portion of water demand not met by surface water supplies without negatively impacting the groundwater basin. Groundwater overdraft can lead to increased extraction costs, water quality degradation, and land subsidence. Land subsidence can result in a permanent loss of aquifer storage space, and may cause damage to public facilities, such as canals, utilities, levees, pipelines, and roads. A significant portion of the state's current annual overdraft occurs in the San Joaquin River hydrologic region (DWR, 2003).

Air pollutants in the Study area will continue to be influenced by urban and agricultural land uses. As the population continues to grow and agricultural lands are converted to urban centers, a general degradation of air quality conditions could occur.

Water Resources Infrastructure/Operations

Several significant projects are expected to be implemented in and near the project area, including:

- **South Delta Improvements Program.** SDIP objectives are to improve the long-term reliability of state and federal water export projects, protect local diversions, and reduce impacts on San Joaquin River salmon. The SDIP is a series of proposed actions to improve water quality and protect salmon in the southern part of the Sacramento-San Joaquin Delta while allowing the SWP to operate more effectively to meet California's existing and future water needs. These actions include construction of an operable gate at the head of Old River, construction of up to three operable gates in south Delta channels, and an increase in the permitted capacity of the Banks Pumping Plant during certain periods. The SDIP has a two-stage decision making process: **Stage 1** addresses the physical/structural improvements (including the new operable gates and dredging and agricultural diversion modifications); and

Stage 2 addresses the proposed operational component to increase water deliveries south of the Delta, and begins after the Stage 1 decision is made.

- **Operations Criteria and Plan.** The CVP OCAP describes the regulatory and physical constraints and conditions under which the CVP and SWP operate. The descriptions of the CVP and SWP in the OCAP are the basis for the BOs that authorize the take of endangered species. Reclamation and DWR export operations must be consistent with OCAP to be covered by permits and BOs. In 2004, a BO for an updated version of the OCAP was issued by NMFS that assessed the effects of continued CVP/SWP operations on listed Chinook salmon and steelhead in the Sacramento River, and coho salmon in the Trinity River. This BO was challenged in court, and the preparation of a new biological assessment (BA)/BO was ordered in December 2007. A revised BO is currently being prepared by NMFS and USFWS. When approved, numerous actions contained in the revised OCAP and projects whose environmental evaluations were based on the OCAP BO (such as the SDIP) will come back online and may or may not be implemented.
- **Bay Delta Conservation Plan.** The BDCP's purpose is to provide for the conservation of at-risk species in the Delta and improve the reliability of the water supply system within a stable regulatory framework. The process is being conducted consistent with state and federal laws that encourage the development of broad habitat conservation plans that protect natural communities in exchange for regulatory assurances. DWR will prepare a joint EIR/EIS for BDCP in cooperation with three federal lead agencies including the NMFS, USFWS, and Reclamation.
- **Other Projects.** Various other projects and programs are expected to be implemented in the future, including renewals of CVP contracts, the Freeport Regional Water Project, and further implementation of CVPIA (b)(2) water accounting.

These and other related future projects will be included and evaluated in the NEPA and CEQA analysis of likely future conditions.

Biological Environment

Significant efforts are underway by numerous agencies and groups to restore various biological conditions throughout the Study area, including elements of the CALFED program, efforts by private conservation groups, and numerous other programs and projects. Accordingly, major areas of Delta wildlife habitat are expected to be protected and restored. However, as population and urban growth continue, and agricultural land is converted to urban uses, wildlife species especially dependent on agricultural habitats may be impacted.

In addition, many programs and projects to help restore fisheries resources are being pursued. Although significant increases in anadromous and resident fish populations are likely to continue through the implementation of restoration projects, these gains may be offset by other actions, such as a reduction in Delta

inflows and associated increases in water temperatures and other effects. Also, beginning in fall 2004 and spring 2005, there have been sharp declines in several pelagic (open-water) species, including longfin smelt, juvenile striped bass, threadfin shad, and Delta smelt—a federal and state endangered species generally considered an indicator of the overall health of the Delta ecosystem. An increase in population and number of invasive species in the Delta is another potential future condition that could impact native species of concern.

In February 2005, the NRDC and five other environmental groups sued the USFWS after the agency ruled that increases in state and federal exports from the Delta would not harm Delta smelt. In April 2007, an Alameda County Superior Court judge ordered the state to stop exporting water from the Delta within 60 days after finding that DWR lacked the proper permits or authority to run the Harvey O. Banks export facility. The state appealed the decision and implemented a voluntary shutdown. In August 2007, U.S. District Court Judge Oliver Wanger ruled that state and federal water project managers must reduce the amount of water exported from the Sacramento–San Joaquin River Delta from the end of the December, when the fish are ready to spawn, until June, when the fish can move out of harm’s way from the export facilities into Suisun Bay. However, the impact on Delta fisheries from this temporary reduction in export/increase in flow is still being determined. Regardless, federal and state environmental laws are expected to have considerable bearing on any future management strategy for the Delta.

Alternative approaches to a comprehensive solution for the Delta’s problems are being evaluated by the State’s Delta Vision process, as well as the BDCP. While the specific objectives of these significant ongoing processes are different, it is likely that changes in the way the Delta is managed are imminent, and significant impacts related to salinity, flows, and the biological environment are expected. These impacts cannot be fully evaluated until Delta Vision and the BDCP make recommendations for implementation.

Social and Economic Environment

Based on 2000 statistics, the population of California will increase 30 percent by 2020 and 70 percent by 2040, from about 35 million in 2000 to nearly 60 million by 2040. The population of the Sacramento Valley will increase 45 percent by 2020 and 90 percent by 2040, from about 2.6 million people in 2000 to 5 million in 2040. Anticipated increases in population growth in the Central Valley will result in increased demands on water resources, energy supplies, water-oriented facilities, recreational facilities, flood damage reduction, and pressure to convert some agricultural and rural land to urban uses. Modification and expansion of existing traffic routes in the Central Valley are anticipated in response to the growing population.

All of the Delta management strategies currently being considered by the Delta Vision and BDCP have associated positive and negative impacts on the social and economic environment. In particular, the current approach to managing the

Delta—with moderate reinforcement of existing levees and net Delta outflows to keep the Delta fresh—prolongs its risks and vulnerabilities, which are likely to increase over time. Alternatives that allow for local specialization and variability in the Delta include levee strategies that would benefit in-Delta agricultural and urban users. Alternatives are under development that modify current water export policies to gain the flexibility to achieve other objectives. While no single preferred scenario is currently proposed, a radically new approach to Delta management is possible, such as from establishing a fluctuating-salinity ecosystem in the western Delta, restoring peripheral areas (such as Suisun Marsh and Cache Slough), allowing urbanization of some Delta lands, constructing an isolated conveyance facility around the Delta, and reinforcing a through-Delta corridor—each with its own environmental, economic, and social consequences.

Cultural Environment

Reclamation has a responsibility to evaluate the potential impacts of its undertakings on cultural resources and Indian Trust Assets when evaluations reveal that impacts may occur. While cultural conditions in the Delta currently are not being degraded because of water quality, some cultural resources might be affected by the implementation of individual projects, such as the discovery of buried archaeological sites. However, absent implementation of the NoCDIS project, significant and unavoidable impacts on cultural resources are not expected. Rather, any paleontological, historical, archeological, or ethnographic resources that are currently being affected (such as by erosion associated with water-level fluctuations) would continue to be affected.

Water Resources Problems, Needs, and Opportunities

This section describes major water resources problems, needs, and opportunities identified in the Study area. Water resources problems, needs, and opportunities provide a framework for plan formulation and help establish project objectives. Water resources problems in the Delta are associated with increasing local and export demands, seasonal salinity variations, hydrologic variations in water availability, and the recent dramatic pelagic organism decline (POD) and endangered fish species that live within and migrate through the Delta.

Problems and Needs

This IAIR has been developed to address two specific problems in the Study area. The first problem to be addressed is quality of water in the south Delta being pumped at the Jones Pumping Plant and the Banks Pumping Plant. The second is fisheries conditions throughout the Delta.

Currently, the interior Delta water quality standards, established by SWRCB D-1641, are difficult to achieve due to the complex hydrodynamics of the Delta and present CVP/SWP operations. Current water quality problems in the Delta may be further exacerbated due to future demands on a fixed water supply and other factors.

Problems and Needs

- ✓ Water Quality Issues at the State and Federal Pumping Facilities
- ✓ Need to Improve Fisheries Conditions Throughout the Delta

It is important to note that while SWP supplies significantly more water for municipal and industrial use, CVP water quality is still a very important issue. A majority of the water delivered through the CVP project is delivered for agricultural use; however, the SWP and CVP systems are connected at a few key points and water is sometimes traded between these two systems (joint point of diversion). Water quality improvements at the CVP and SWP pumping facilities will enhance and benefit both systems.

Based on the overall authority of the NoCDIS and the without-project conditions described in Chapter 3, the following is a summary of the major water resources problems, opportunities, and needs identified in the primary Study area.

Delta Salinity and Agricultural Drainage

Before there were water projects in the Central Valley, the transition point from freshwater to saltwater in the Delta was primarily controlled by the natural flow and runoff of the San Joaquin and Sacramento River systems. In late summer and fall, when river flows were lowest, saltwater would intrude far into the Delta. In winter and spring, high flows from the rivers and snow melt would wash the salinity position back toward the ocean. After the water projects were constructed, continuous flows of freshwater have generally attenuated this natural ebb and flow of salinity in the Delta. However, problems of seasonal salt intrusion from the ocean or accumulation of minerals from farming discharge into Delta rivers remains a problem.

Delta water quality standards (Standards) are regulated by the SWRCB. These Standards are achieved by the interaction of upstream reservoir releases by the CVP and the SWP, ocean-derived salinity (through tidal action) and land-derived salinity (Delta agricultural returns), and diversions from the Delta (primarily by the CVP and SWP). Originally, these interactions resulted in Standards reflected primarily at monitoring locations largely influenced by ocean-derived salinity.

Historically, the need to keep salty water away from rich farmland in the Delta has been a priority. Most Delta islands are below sea level, and water from surrounding channels seeps through levees onto the land. Delta farmers must pump this water from the lands while adding controlled amounts of freshwater to maintain productive farmland. In the south Delta, where farmers rely primarily on San Joaquin River water, the process of irrigation concentrates salts in the drain water, which is then pumped into nearby Delta channels. At certain times of the year, there is no “flushing-flow,” and localized salinity problems are created.

Drinking Water Quality and the State Water Project

Because so much SWP water is used for drinking water, maintaining high water quality at the SWP intake has always been a high priority. Water quality concerns in the vicinity of the SWP intake historically have revolved around salt and salinity issues, but water quality issues now include potential contamination from mercury, selenium, bromide, and organic carbon. Organic carbon is a precursor to the formation of THMs.

Trihalomethanes

THMs are a group of organic chemicals formed in water when chlorine reacts with natural organic matter (such as humic acids from decaying vegetation). Humic acids are present in all natural water used as sources of drinking water. Total THMs are not a single chemical, but rather a class of compounds. Chlorine reacts with the natural organic carbon compounds in the water to form THMs. Some scientific studies have linked THMs to increased risk of cancer. Several studies suggest a small increase in the risk of bladder cancer and colorectal cancer. Beyond the cancer and reproduction concerns, some investigations have

found that chlorination byproducts may be linked to heart, lung, kidney, liver, and central nervous system damage. Many water treatment facilities are taking steps to reduce or eliminate chlorine use to help solve this problem. Delta islands are made up largely of peat soils that, when plowed, tend to mobilize organic carbon, which then becomes available for THM production. THMs will likely be an ongoing concern to drinking water quality in the Delta and to export users.

Bromide

Bromide presents a similar drinking water concern as THMs. Bromide sources come primarily from saltwater intrusion and agricultural return flows. When mixed with organic carbon, bromide can react in the ozonation water-treatment process to form bromate, a known carcinogenic.

Pesticides, Selenium, and Mercury

Agricultural runoff and agricultural drainage are the primary sources of pesticide and selenium entering the Delta. Most of the mercury in the Delta can be related to the significant amount of 19th century mining that occurred in the watersheds that feed into the Delta.

Total Maximum Daily Loads in the Delta

The Central Valley Regional Water Quality Control Board (Water Board) is developing and implementing numerous TMDLs for constituents that impair aquatic life beneficial uses in the Delta, including organophosphate pesticides, mercury, low DO, salt and boron, selenium, and bacteria. The organophosphate pesticide TMDL for Delta waterways was approved by the EPA in October 2007. A TMDL for salt and boron at Vernalis was approved by the EPA in July 2006, and a salt and boron TMDL for the San Joaquin River upstream of Vernalis will be subject to peer review in 2008; it should be considered for adoption in 2009. The TMDL for low DO in the Stockton Deep Water Ship Channel was approved by the EPA in August 2006. The Water Board is conducting fish tissue and water column analyses to monitor impairment by methylmercury as part of the proposed methylmercury TMDL.

Salinity in the Central Valley

Elevated salinity in surface water and groundwater in California's Central Valley is an increasing problem. The Water Boards have initiated a comprehensive effort to address salinity problems in the Central Valley and to adopt long-term solutions that will lead to enhanced water quality and economic sustainability—this is referred to as Central Valley Salinity Alternatives for Long-Term Sustainability. The SWRCB and Central Valley Water Boards have established a Policy Group to help develop a Central Valley Salinity Management Plan. Four committees of the Policy Group have been meeting regularly to discuss program development, as well as technical, economic, and public outreach components of

the project. Work is being conducted under contract to evaluate the economic impacts of not addressing salinity, and assessing data gaps.

Water Quality and Delta Fish

Two major events since 2005 have spurred an unprecedented level of focus and debate on the problems and issues in the Delta related to fish.

Pelagic Organism Decline: In the last few years, the abundance indices calculated by the Interagency Ecological Program (IEP) Fall Midwater Trawl Survey and Summer Trawl Survey show marked declines in numerous pelagic fishes in the upper San Francisco Estuary (the Delta and Suisun Bay) (IEP, 2006). The abundance indices for 2002 to 2004 include record lows for Delta smelt and age-0 striped bass, and near-record lows for longfin smelt and threadfin shad. POD is one of the major driving forces for study in the Delta.

Ordered Pump Shutdown for Delta Smelt (2007): On June 1, 2007, all of the export pumps for the SWP were shut off to protect Delta smelt, and all but one pump at the federal facility was shut down. In essence, all water exports to southern California stopped. During this period, the San Luis Reservoir was drawn down at a rate of 2 feet per day to maintain water deliveries in the region. The pumps were brought back online after approximately 10 days, but the action emphasized water supply vulnerability to Delta ecosystem conditions and subsequently led to a renewed focus on finding a Delta solution from all the stakeholders, including DWR and Reclamation.

Monitoring conducted by the IEP has shown declines in the abundance of four pelagic fish species in the upper San Francisco Estuary. Abundance indices for 2002 and 2004 demonstrate record lows for Delta smelt and young-of-year striped bass, and near record lows for longfin smelt and threadfin shad. In contrast, no pelagic fish species inhabiting the lower estuary or San Francisco Bay shows a similar decline. Therefore, it appears that the POD is confined to the upper estuary and freshwater Delta.

In response to these concerns, staff from the SWRCB and the San Francisco Bay and Central Valley Water Boards formed the Bay-Delta Team to improve coordination of the Water Boards' activities in the Bay-Delta. In 2007, the Bay-Delta Team began developing a long-term program for addressing impacts to beneficial uses of water in the Bay-Delta. At that time, staff recognized that in addition to long-term planning, there was need to identify actions that should be implemented immediately to control known or suspected impairments (e.g., studies to assess impacts of ammonia on Delta species) and short-term actions that would contribute to development of the comprehensive program (e.g., development of a comprehensive monitoring and assessment strategy). At this time, the SWRCB and Regional Water Boards are taking steps to integrate and improve Delta-wide water quality monitoring to help determine the relationship between water quality and POD.

Anadromous Fish Survival

Chinook salmon populations were heavily impacted by the implementation of water projects in the 20th century. Through much of the 1990s, significant progress has been made and considerable monies expended to maintain and/or rebuild anadromous fish populations in the Sacramento and San Joaquin Rivers systems. Water agencies and diverters have spent millions of dollars to screen and upgrade facilities to minimize juvenile take at pump stations along the Sacramento River. Improved fish passage and temperature control structures have been installed, and environmental water has been made available for fish and riparian species. Environmental factors are now a part of the overall operation of the water system in California, and salmon numbers in the Central Valley were maintaining or improving in the late 1990s and early 2000s.

Since 2005, however, salmon numbers have been in significant decline. In 2007, an estimated 87,996 fall-run Chinook natural and hatchery adults returned to the Sacramento River. This is the second lowest return on record, and is below the lower boundary of the Pacific Fishery Management Council conservation goal of 122,000 to 180,000 adults. In addition to the missed conservation objective, the 2008 Central Valley fall Chinook jack returns (5,939 jacks) are at a record low level. The annual Central Valley jack returns are used to calculate Central Valley ocean abundance. The reason for this recent downturn in salmon returns is unclear at this time.

Recent Listings

The Delta is home to five threatened or endangered fish species, including: Central Valley spring-run Chinook salmon (2005), Sacramento River winter-run Chinook salmon (1994), Delta smelt (2003), green sturgeon (2006), and steelhead (1998). Central Valley fall- and late-fall-run Chinook were listed as a species of concern in 2004. In August 2007, the Bay Institute, Center for Biological Diversity and Natural Resources Defense Council formally requested that the CDFG Commission list the longfin smelt (*Spirinchus thaleichthys*) as an endangered species under the CESA on an emergency basis. These environmental groups are also petitioning the federal government for listing under the FESA. Determinations under both the CESA and FESA are due in 2008.

Opportunities

Many opportunities were identified through the CALFED Program to construct structures in the north or central Delta, or modify current structures, that would result in improved water quality. CALFED also identified a number of habitat or structural improvements that could be made to improve fishery conditions in the Delta. Many of the opportunities that exist to improve water quality can also be implemented to improve conditions for fisheries. Reclamation, through NoCDIS, will investigate the opportunities to both reduce salinity levels and improve fishery conditions throughout the Delta.

Since the Flooded Islands Pre-Feasibility Study in 2005, DWR's Bay-Delta Office has continued technical studies, conceptual designs, cost estimates, and water quality modeling in support of facilities at Franks Tract for water quality and fisheries benefits. These feasibility-level studies have resulted in five alternatives. In addition to the Franks Tract alternatives, Reclamation's NoCDIS Plan of Study (August 2007) included other alternatives in the north and central Delta with similar potential to meet the planning objectives.

For the IAIR, the opportunities/alternatives have been identified and evaluated, and will be screened to determine which has the highest potential benefit to both water quality and fisheries. These opportunities include facilities in the north and central Delta initiated by CALFED or DWR, as well as water management opportunities to meet NoCDIS planning objectives.

Plan Formulation Approach

This chapter discusses the process of formulating plans for the NoCDIS and presents the planning objectives, constraints, and criteria for the Study.

Plan Formulation Process

Consistent with the Federal Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (WRC, 1983), the basic plan formulation process includes the following steps:

- Identifying existing and projected future resource conditions without implementation of a project.
- Defining water resources problems and opportunities to be addressed.
- Developing planning objectives, constraints, and criteria.
- Identifying resources management measures and formulating potential alternative plans to meet Study objectives.
- Comparing and evaluating alternative plans.
- Identifying a plan that best meets planning criteria and maximizes net National Economic Development (NED) benefits.

This IAIR identifies, discusses, and screens measures to address the problems and opportunities. These measures are used to develop initial alternatives. Initial alternatives will be incorporated into and refined in the subsequent PFR. Conclusions and recommendations will evolve to incorporate the results of future technical evaluations as the investigation progresses. The final phase in the process will produce a Feasibility Report, combined with supporting environmental documentation.

For the NoCDIS, the above process is being separated into three phases, as shown in Figure 5-1 and described as follows:

- **Initial Alternatives Phase**—Identify without-project future conditions, define resulting resources problems and opportunities, define a specific set of planning objectives, and identify the constraints and criteria in addressing the planning objectives. Identify potential resources management measures to address planning objectives; formulate, coordinate, and compare a set of concept plans; and identify a potential federal interest for implementation of a project.
- **Plan Formulation Phase**—From the initial alternatives, refine specific alternative plans to address the planning objectives, evaluate and compare the

plans, and identify one or more plans for feasibility-level evaluation, including the preliminary NED plan.

- Feasibility Report and EIS/EIR Phase—Complete the feasibility-level analysis and EIS/EIR, identify the NED plan, confirm financial feasibility, and identify the federal interest if federal participation in implementation of a plan is recommended.

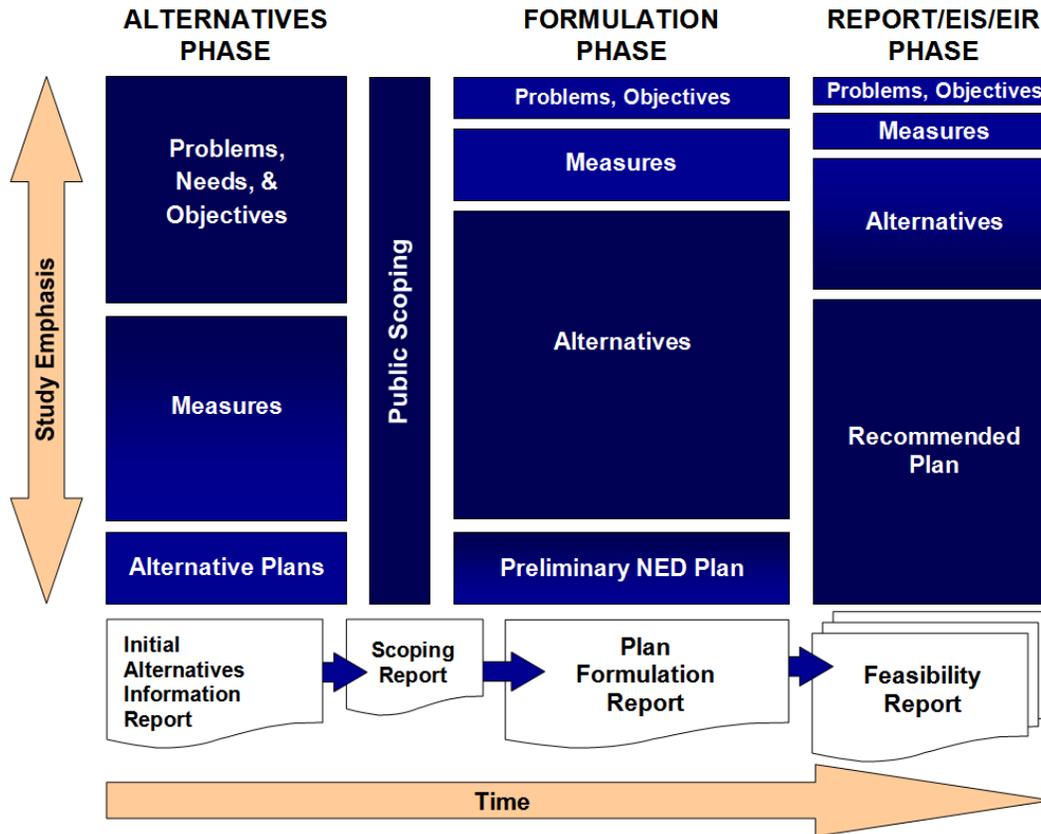


FIGURE 5-1
Plan Formulation Diagram

Planning Objectives

On the basis of the previously identified and defined problems and opportunities in the Study area and in relation to Study authorities, the following planning objectives were developed. These objectives are to be used to help guide formulation of alternatives to address the water resources problems:

- Improve the quality of water in the south Delta being pumped at the CVP Jones Pumping Plant (formerly known as the Tracy Pumping Plant) and the SWP Banks Pumping Plant while remaining consistent with long-term Delta planning efforts.
- Improve fisheries conditions throughout the Delta while remaining consistent with long-term Delta planning efforts.

Planning Constraints

Planning constraints guide the direction of the NoCDIS Feasibility Study process. These constraints include Congressional direction (i.e., study authorizations) and existing water resources projects and programs. Planning constraints, such as biological, cultural, and socioeconomic resources; hydrology; and topography can also be specific to proposed project locations. Specific planning constraints identified for the NoCDIS investigation include the following:

- **Inter-related and Evolving Delta Issues**—The problems in the Delta are forcing significant efforts to find a long-term solution. Several key Delta investigations are underway that will likely yield a comprehensive Delta action plan in the future. Delta Vision, DRMS, BDCP, and others listed in Chapter 2 will likely influence the NoCDIS planning process as it moves forward.
- **Study Authorizations**—The Feasibility Study authorization for Franks Tract was provided by Public Law 108-361. This authorization was set to expire at the end of fiscal year 2010, but has been extended to 2014.
- **Laws, Regulations, and Policies**—Laws, regulations, and policies that must be considered include, but are not limited to, NEPA, CEQA, USFWS Coordination Act, National Historic Preservation Act, FESA and CESA, CVPIA, and the Magnuson-Stevens Fisheries Conservation and Management Act.

Criteria for Formulating and Evaluating Alternatives

In addition to the planning constraints, a series of planning principles and guidelines help guide plan formulation and planning criteria for consideration, not only in formulating the initial set of alternatives, but also to determine which alternatives best address the planning objectives. Many of the planning principles and guidelines are included in the Federal Water Resources Council's Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (WRC, 1983) and other federal planning regulations. The principles and guidelines include four specific criteria for use in screening potential alternatives: completeness, effectiveness, efficiency, and acceptability. The criteria are defined as follows:

- The completeness criterion addresses whether the alternative would account for all investments or other actions necessary to realize the planned effects.
- The effectiveness criterion addresses how well an alternative would alleviate problems and achieve opportunities. This criterion considers how well the alternative would achieve the planning objectives of water quality and fisheries improvement.
- The efficiency criterion addresses the extent to which an alternative plan is the most cost-effective means of alleviating the specified problems and realizing

the specified opportunities consistent with protecting the nation's environment.

- The acceptability criterion addresses the viability of an alternative with respect to acceptance by state and local entities, and compatibility with existing laws.

CHAPTER 6

Objectives and Resource Management Measures

The CALFED Bay-Delta Authorization Act of 2004 (Pub.L. 108-361, Section 103) authorized the Department of the Interior to carry out a feasibility study for Franks Tract. The Delta Cross Channel and TDF were subsequently combined in this one study to determine the effectiveness of the actions individually and in combination to achieve the NoCDIS planning objectives. This IAIR will develop initial alternatives (focusing on the areas and facilities listed previously) to contribute to the plan formulation phase of the Feasibility Study.

The objectives of the NoCDIS are to:

- Improve water quality at the south Delta export facilities while remaining consistent with long-term Delta planning efforts.
- Improve fisheries conditions throughout the Delta while remaining consistent with long-term Delta planning efforts.

Resource Management Measures were identified to meet the two objectives of the project. Measures were developed in the IAIR phase by collecting information on past projects and studies based on some studies already completed by DWR. Some measures were eliminated because they were deemed infeasible or did not best meet the Study's objectives. The measures retained for further consideration were combined into a set of initial alternatives. The challenge faced in developing the alternatives was to balance the need to deliver freshwater with maintaining and improving fish habitat.

Developing a suite of effective Resource Management Measures requires an understanding of the facilities and hydrodynamics driving the water quality and fisheries problems, needs, and opportunities. Freshwater from the Sacramento River reaches the central Delta via the Delta Cross Channel and Georgiana Slough. Middle River and Old River provide a corridor where freshwater is conveyed from the north and central Delta to the south Delta. During times of low net Delta outflow and high south Delta water exports, high-salinity water can intrude into the central Delta from the Pacific Ocean to the west. The high-salinity water typically travels east up the San Joaquin River near Jersey Island, east along the West False River channel into Franks Tract, and south into Rock Slough and Old River. This water mixes with the fresher water in Franks Tract as it is conveyed to the SWP and CVP export facilities.

Less is known about hydrodynamic effects on fish behavior. During times of low net Delta outflow and high south Delta water exports, juvenile fish tend to follow the increased flows toward the export facilities rather than continuing their

outmigration to the ocean. High river outflow is associated with higher abundance of the Delta pelagic fish such as Delta smelt (IEP, 2008), and low river outflow is associated with lower abundances of pelagic fish. For longfin smelt, downstream transport and distribution of larvae within the estuary has been shown to vary positively with outflow (Baxter, 1999; Dege and Brown, 2004, as cited by IEP, 2008). Kimmerer and Nobriga (2008) recommended that strong protective measures for Delta smelt be provided in spring months of low outflow water years when these fish are highly vulnerable to export losses.

Objective 1—Improve Water Quality

Increased salinity levels in the Delta at certain times of various hydrologic year types hinder CVP and SWP operations, and result in the delivery of poorer quality water to water contractors within and south of the Delta. The first objective is therefore to improve the quality of water in the south Delta being exported at the Jones Pumping Plant (formerly known as the Tracy Pumping Plant) and the Banks Pumping Plant.

Studies performed by DWR (see Chapter 8) have determined that increasing the net outward flow in the lower San Joaquin River near Jersey Point helps to repel the salinity as it intrudes from the west. In addition to increasing flows down the San Joaquin River, increasing the transfer of Sacramento River water to the central Delta or reducing SWP and CVP exports may have the effect of reducing salinity at the export facilities.

The DCC facility was constructed to serve the critical role of transferring additional Sacramento River water to the central Delta. When the DCC gates are open, additional water is transferred from the Sacramento River to the central Delta via the Mokelumne River system. DWR studies have shown that re-operating the gates or modifying the hydrodynamics in the area could provide additional water quality benefits.

Analyses conducted as part of previous studies have concluded that water quality benefits could also be achieved by constructing adjustable barriers in the Franks Tract area to alter the tidal flow in that region. Previous studies have also examined constructing facilities that re-route flow through the central Delta.

Measures Considered

Improved water quality at the south Delta export facilities could be achieved by reducing or mitigating the salinity intrusion into the central Delta from the west (from the Pacific Ocean). Several measures were identified as having the potential to accomplish this:

- 1.1 Increase transfer of Sacramento River flows to the central Delta.
- 1.2 Increase Mokelumne River flows delivered to the central and south Delta.
- 1.3 Reduce tidal and seasonal mixing from the west Delta into Franks Tract.
- 1.4 Increase the net outflow in the lower San Joaquin River near Jersey Point.
- 1.5 Isolate a “fresh water corridor” minimizing mixing with west Delta waters.

- 1.6 Create a longer path for higher salinity water to reach export facilities by creating physical flow barriers.

Objective 2—Improve Fisheries Conditions

A number of fisheries problems exist throughout the Delta. Among those fisheries issues identified through CALFED, the recent decline in pelagic organisms has contributed to reduced CVP/SWP project operations and water deliveries. Species that are particularly sensitive to Delta operations include Delta smelt (*Hypomesus transpacificus*), Chinook salmon (*Oncorhynchus tshawytscha*), and steelhead trout (*O. mykiss*). Recent litigation has further reinforced the need to enhance fisheries in the Delta.

Studies with marked Chinook salmon smolts have indicated that migration into the Central Delta via the Delta Cross Channel or Georgiana Slough negatively affects survival as the fish migrate through the Delta (Brandis and McLain, 2001). The IEP believes that the Delta smelt population is affected by the amount of outflow from the Estuary, which varies from year to year due to precipitation and water management. For Delta smelt, a positive relationship has been observed between the fall mid-water trawl abundance index and the number of days the entrapment zone (where saltwater and freshwater meet) is in Suisun Bay from February through June. This suggests that the Delta smelt population improves when outflow is allowed to flow downstream because nursery habitat is created in Suisun Bay (CDFG, 2008a).

Additionally, IEP has identified a relationship between freshwater outflow and longfin smelt abundance. The overall effect of high freshwater outflow appears to be an increase in the amount and quality of nursery habitat for this species in San Pablo Bay and a broader dispersal of young fish. Low freshwater outflows during the winters of 1987 through 1992 are believed to be responsible for the decline in longfin smelt during that period (CDFG, 2008b).

Measures Considered

Several measures were identified as having the potential to protect sensitive fish species conditions in the Delta:

- 2.1 Physically prevent sensitive species from entering the central and south Delta from the north and west Delta when the export facilities are operating.
- 2.2 Alter flow operations to encourage fish to remain in the Sacramento River system where mortality rates have been shown to be lower than in the central Delta and Mokelumne River system.
- 2.3 Physically prevent anadromous species from entering the central Delta, keeping them in the Sacramento River system rather than the Mokelumne River system when outmigrating from the north.

Chapter 6: Objectives and Resource Management Measures

- 2.4 Alter flow operations to negate reverse flows in the central and south Delta, encouraging fish to remain in the north Delta or outmigrate to sea.
- 2.5 Install physical barriers to negate reverse flows in the central and south Delta, preventing fish from entering the area of the export facilities from the north and east.
- 2.6 Install fish screening devices at major diversions.

Measures Retained for Further Consideration

Of the measures considered, all were retained for further consideration. Measures 1.1, 1.2, and 1.4, developed to address Objective 1, may also have a secondary benefit of improving fisheries.

Development of Initial Alternatives

The Resource Management Measures identified in Chapter 6 were expanded and combined into a set of initial alternatives described in this chapter. The initial alternatives also were developed in the context of DWR's ongoing efforts to implement a Franks Tract project, and continuing investigations of possible water quality and fisheries improvement projects in the north and central Delta. Previous alternative screening documentation is also presented here, prior to comparison of alternatives in Chapter 8.

Overview of Alternatives

The initial alternatives are organized into Franks Tract Alternatives, Through-Delta Alternatives, and Delta Cross Channel Alternatives to meet CALFED Bay-Delta Authorization Act authorities. Additional management alternatives that were identified are included in this Study. Figure 7-1 provides a NoCDIS vicinity map. The initial alternatives considered include:

- Franks Tract Alternatives
 - Alternative A: Operable Gates on West False River
 - Alternative B1: North Levee and Two Operable Gates
 - Alternative B2: East Levee and Two Operable Gates
 - Alternative C: Gates on Holland Cut and Old River (Cox Alternative)
 - Alternative D: Operable Gates on Three Mile Slough
- Through-Delta Alternatives
 - Alternative E1: Through-Delta Facility (original CALFED facility and alignment)
 - Alternative E2: Through-Delta Facility (alternative concept)
- Delta Cross Channel Alternatives
 - Alternative F1: Delta Cross Channel Modifications and Re-operation
 - Alternative F2: Delta Cross Channel Re-operation Only
- Management Alternatives
 - Alternative G: Mokelumne River Water Exchange
 - Alternative H: Outflow Management/Sacramento River Flow Augmentation

Franks Tract Alternatives

Franks Tract is one of the largest of several Delta islands that was reclaimed for agriculture by constructed levees and subsequently flooded. Franks Tract, flooded by levee breaches in the late 1930s, is now connected to the Delta by False River, Fisherman's Cut, Old River, Holland Cut, Sand Mound Slough, and Piper Slough.

Analyses conducted by DWR as part of the Flooded Islands Pre-feasibility Study (DWR, 2005) and other related studies identified Franks Tract as having the potential, with modifications, to improve water quality in the south Delta. These pre-feasibility studies have indicated that salinity reductions could be achieved by constructing and operating gates in and around Franks Tract to alter tidal influences or residence time in the central Delta. DWR's Pre-feasibility Study process identified several potential Franks Tract alternatives. The DWR analysis determined that some identified alternatives were not cost effective, and were therefore omitted from this list of initial alternatives. Analysis supporting preliminary screening of Franks Tract alternatives by DWR was focused on gate operations to maximize the water quality improvement objective, but gate operations to benefit fish are currently in development.

The four alternatives remaining from the 2005 study (Alternatives A, B1, B2, and C) are included in this IAIR analysis. Subsequent to the 2005 study, DWR developed a fifth alternative involving Three Mile Slough (Alternative D), which is also included in this IAIR. These five Franks Tract alternatives are described below. Figure 7-2 shows the Franks Tract region and nearby Delta channels and rivers with approximate locations of facility options for the Franks Tract alternatives.

Alternative A: Operable Gates on West False River

This alternative involves installing operable gates on the West False River near the confluence with the San Joaquin River west of Franks Tract. The gates would provide a physical obstruction to salt intrusion entering Franks Tract via the western end of False River. When gates on the flood side block the tidal flow, water would be directed farther up the San Joaquin River around Bradford Island and Webb Tract, creating a longer path for higher-salinity water to reach the export facilities (Measure 1.6). The gates would also prevent saltwater from entering Franks Tract during the flood tide and becoming trapped and mixed in Franks Tract (Measure 1.3).

The gates would be operated on both a seasonal and tidal basis. The current alternative for gate operation anticipates closing the gates approximately 12 hours per day. Base condition peak tidal flow in False River is about 50,000 cfs. With False River closed, this flow would largely be diverted to the San Joaquin River north of Bradford Island and Webb Tract. A portion of the flow would reenter the western end of Franks Tract along Fisherman's Cut. Tidal flow in Fisherman's

This page intentionally left blank.

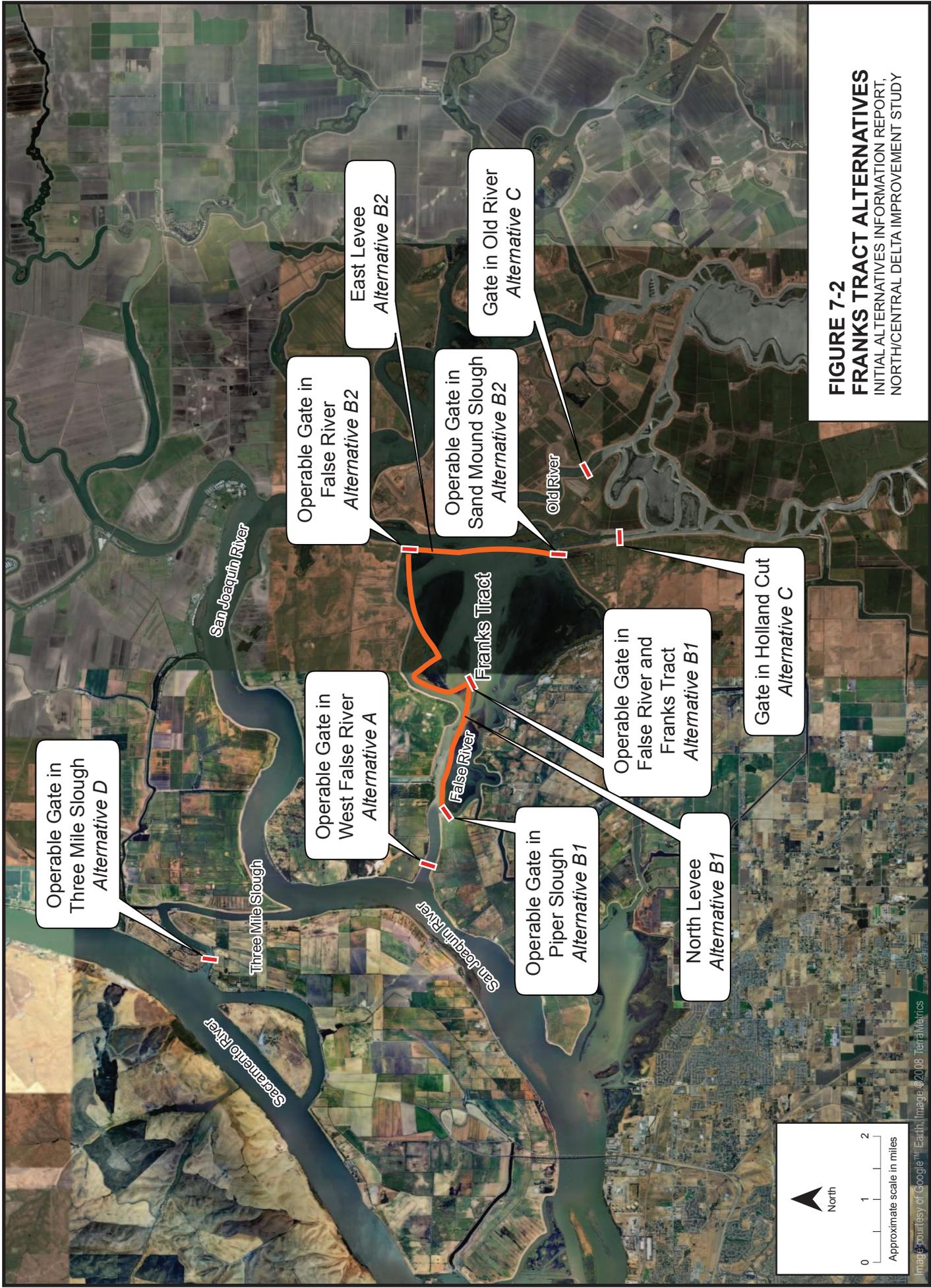


FIGURE 7-2
FRANKS TRACT ALTERNATIVES
 INITIAL ALTERNATIVES INFORMATION REPORT,
 NORTH/CENTRAL DELTA IMPROVEMENT STUDY

This page intentionally left blank.

Cut would increase from about 2,000 cfs to nearly 10,000 cfs. Channel velocities would increase from about 0.5 foot per second (fps) to about 2.5 fps. The bulk of the diverted flow would reenter the northeast corner of Franks Tract along the Old River channel connecting Franks Tract to the San Joaquin River. Peak tidal flow would increase from the base condition value of about 13,000 cfs to nearly 40,000 cfs. South of Franks Tract, the gate closure would reduce tidal flow in Old River near Bacon Island by approximately 20 percent. Tidal flow in Middle River near Bacon Island would remain largely unchanged, and tidal flow would increase for Turner Cut, although peak velocity would remain less than 1 fps.

Alternative A is carried forward to the IAIR analysis in Chapter 8.

Alternative B1: North Levee and Two Operable Gates

This alternative involves reconstructing the Franks Tract north levee and installing operable gates between False River and Franks Tract and on Piper Slough. This alternative is intended to reduce tidal and seasonal mixing from the western Delta (Measure 1.3).

Subsequent to the Pre-feasibility Study Report, DWR conducted a cost-benefit analysis on Alternative B1. This analysis showed that water quality benefits would not be as substantial as other less-expensive alternatives. For this reason, Alternative B1 was eliminated from further study by DWR and is not discussed further in this IAIR.

Alternative B2: East Levee and Two Operable Gates

This alternative involves reconstructing the Franks Tract east levee and installing operable gates on the east end of False River and on Sand Mound Slough. This alternative is intended to isolate flow into Old River from Franks Tract (Measure 1.5). Tidal flow would be permitted into Franks Tract from the west but blocked from flowing east into Old River (Measure 1.3).

Subsequent to the Pre-feasibility Study Report, DWR conducted a cost-benefit analysis on Alternative B2. This analysis showed that water quality benefits would not be as substantial as other less-expensive alternatives. For this reason, Alternative B2 was eliminated from further study by DWR and is not discussed further in this IAIR.

Alternative C: Gates on Holland Cut and Old River (Cox Alternative)

This alternative involves seasonal installation of non-operable flashboard gates on Old River and Holland Cut immediately south of Franks Tract. For the Flooded Islands Pre-Feasibility Study, DWR assumed the gates were placed in Old River and Holland Cut during the summer and fall when flows are low and water quality in the south Delta deteriorates. The gates would serve to isolate flow from Franks Tract to the south Delta (Measures 1.3 and 1.5) to improve water quality conditions at export locations.

In the Flooded Islands Pre-Feasibility Study, DWR concluded that the Cox Alternative had potential to improve water quality. DWR continued to study the Cox Alternative after the Flooded Islands Pre-Feasibility Study. These subsequent

studies indicated that, relative to Alternative A (Operable Gates on West False River, described previously) and Alternative D (Operable Gates on Three Mile Slough, described as follows), the Cox Alternative was less effective at improving water quality in the south Delta and was detrimental to water quality in the central Delta (Victoria Canal intake). Because of the other alternatives' effectiveness, DWR eliminated the Cox Alternative from further consideration; therefore, this alternative is not evaluated further in this IAIR.

Non-operable and operable gates on channels south of Franks Tract that are similar to the Cox Alternative, but different in terms of seasonal timing and objectives are being studied in other forums. These gate proposals focus on the objective of reducing the potential entrainment of Delta smelt in the south Delta during the winter and spring rather than improving water quality in the summer and fall like the Cox Alternative. Because gates on channels south of Franks Tract represented in this IAIR by the Cox Alternative are not as effective at meeting the NoCDIS objectives as other alternatives, they are not studied further in this IAIR.

Alternative D: Operable Gates on Three Mile Slough

This alternative involves installation of operable gates on Three Mile Slough between the Sacramento and San Joaquin Rivers north of Franks Tract to regulate flow between the two rivers. Salinity would be reduced at the export facilities by increasing outward flows in the western part of the San Joaquin River (Measure 1.4). Under this alternative, the gates would be closed during portions of the ebb tide to isolate and force more central Delta freshwater down the lower San Joaquin River channel rather than allowing it to enter the Sacramento River via Three Mile Slough (Measures 1.3, 1.5, and 2.4).

Of the four Franks Tract alternatives, Alternative D should have the least effect on Delta hydrodynamics. Three Mile Slough connects the two major tidal flow channels in the western Delta, the Sacramento River, and the San Joaquin River. Peak tidal flow for the Sacramento River near Emmaton and the San Joaquin River near Jersey Point is more than 120,000 cfs. The peak flow in Three Mile Slough is approximately 25,000 to 30,000 cfs in both the ebb and flood tide directions. Therefore, blocking ebb flow on Three Mile Slough for a few hours each day would have only minor effects on the tidal flows and velocities in the Delta. The Operable Gates on Three Mile Slough alternative is designed to divert a few thousand cfs in daily average flow from the Sacramento River to the San Joaquin River.

Potential also exists for this facility to be operated during other times of the year to provide substantial fisheries benefits (Measure 2.1). The Three Mile Slough barrier could be closed to deter sensitive fish species (such as Delta smelt) from entering the central and south Delta from the Sacramento River (Measures 2.2 and 2.4). It could also reduce entrainment of migrating salmon and steelhead in the central and south Delta by forcing them to remain in the Sacramento River at this location (Measures 2.3 and 2.4).

This alternative could be combined with DCC operations to provide fisheries benefits, as discussed in Alternatives F1 and F2. Alternative D is carried forward to the IAIR analysis in Chapter 8.

Through-Delta Alternatives

Several alignments have been proposed as part of previous efforts for a screened diversion facility to transfer water between the Sacramento and Mokelumne Rivers. The additional flow of freshwater into the central Delta (Measure 1.1) would repel the salinity intrusion from the west, resulting in improved water quality in the south Delta near the export facilities. The CALFED conveyance actions in the north Delta region included evaluation of a screened TDF on the Sacramento River for up to 4,000 cfs. The facility, as described in the CALFED ROD, most likely would include a screened diversion near Hood.

Alternative E1: Through-Delta Facility (Original CALFED Facility and Alignment)

This alternative involves construction of a diversion structure on the Sacramento River near the town of Hood and facilities to convey Sacramento River water to the South Fork of the Mokelumne River at New Hope Tract. An approximate alignment of the TDF developed by DWR in the Pre-feasibility Study is shown in Figure 7-3. This alternative would provide water quality benefits in the central and south Delta by increasing the transfer of Sacramento River flows to the central and south Delta (Measure 1.1) while also providing screening protections for fish (Measure 2.5).

Conveyance facilities would include a 4,000-cfs capacity, 13-mile-long canal, and siphons to cross major watercourses (such as Stone Lakes). The diversion would be screened to prevent fish entrainment. The outfall would be screened or would have a fish collection facility (ladder and bypass) to capture and return fish that were attracted up the canal. The alignment, facility components, and technical feasibility of a diversion facility were being further evaluated by DWR and CALFED technical work groups through 2007. To maximize benefits and resolve fisheries concerns, operations of the TDF could be established in conjunction with a new operations strategy at DCC.

Alternative E1 is carried forward to the IAIR analysis in Chapter 8.

Alternative E2: Through-Delta Facility (Alternative Concept)

The proposed TDF would be achieved by conveying Sacramento River water in established Delta channels and gating intersecting channels to control tidal saltwater influences. This corridor could include a new canal configuration starting at a diversion on the Sacramento River near Hood or a diversion into Snodgrass Slough, which would require widening and deepening. The northern reach of the TDF would convey Sacramento River water to the North and South Forks of the Mokelumne River in the central-eastern portion of the Delta. Existing Delta channels south of the Mokelumne River would form a corridor

conveying freshwater toward Clifton Court Forebay. All levees along the selected corridor would be reinforced as necessary.

Alternative E2 is eliminated from further consideration because the southern extension of the freshwater corridor is outside of the geographic scope of this Study (limited to the northern and central Delta). In addition, the northern facilities (e.g., diversion and canal) are too similar to Alternative E1, which is included in the CALFED ROD and this Study.

Delta Cross Channel Alternatives

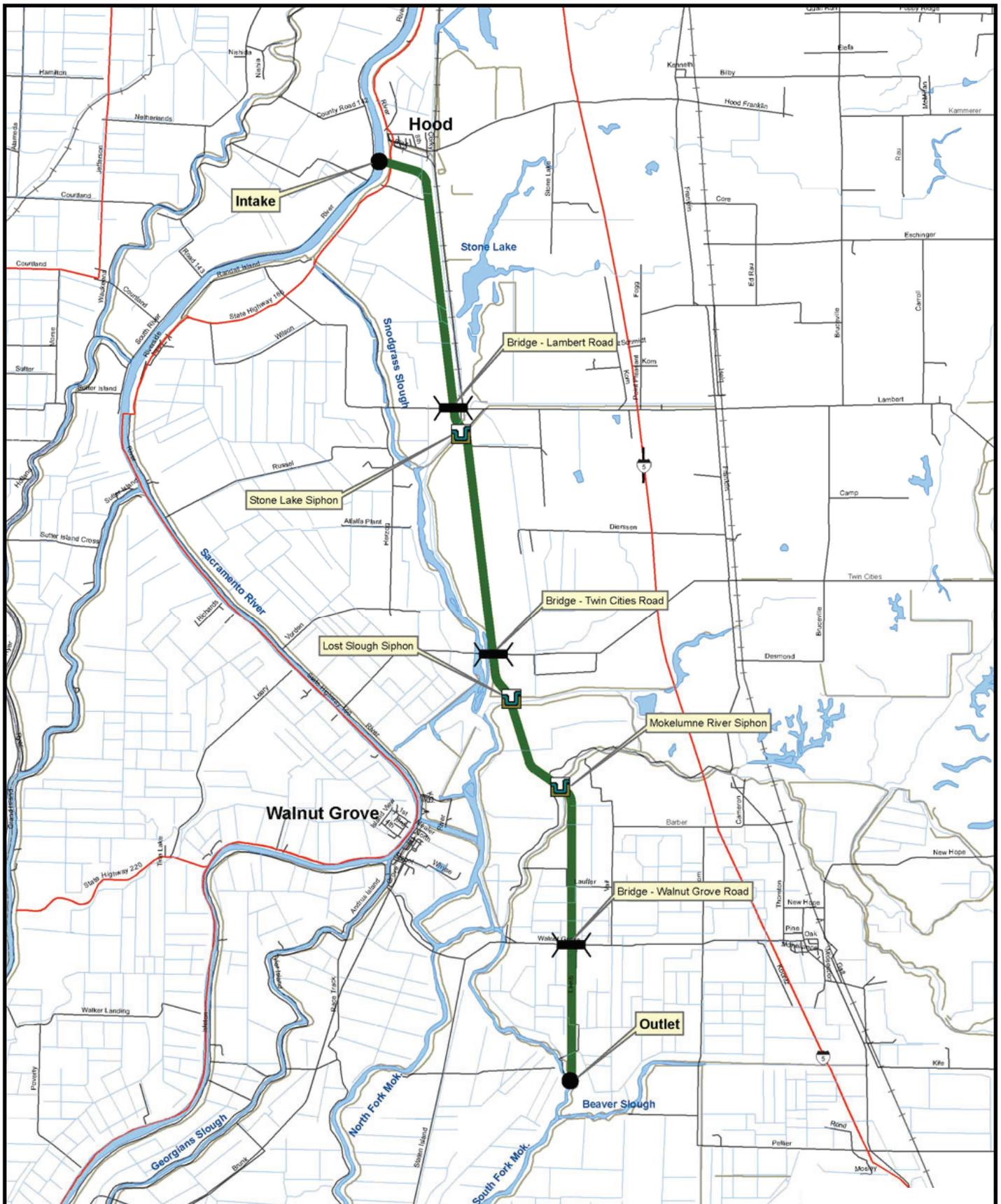
The DCC is a controlled diversion channel between the Sacramento River and Snodgrass Slough near Walnut Grove, designed by Reclamation to transfer more Sacramento River freshwater to the central Delta by way of the Mokelumne River. The location of the DCC is shown in Figure 7-4.

The channel has a design capacity of 3,500 cfs; however, summertime tidal flows in the channel reach nearly 9,000 cfs or higher during high flow periods in the Sacramento River. Freshwater is drawn from the Sacramento River through the 0.75-mile DCC to the Mokelumne River. The water then flows through natural channels for about 50 miles to the vicinity of the Jones Pumping Plant. When the gates are open, the diversion provides an adequate supply of water to the intakes of the Contra Costa Canal and the Delta-Mendota Canal and improves the irrigation supplies in the Delta. Reclamation closes the gates, shown in Figure 7-5, of the DCC during high water to prevent flood stages in the Mokelumne section of the Delta, and also in the fall to protect juvenile outmigrating salmon.

Alternative F1: Delta Cross Channel Modifications and Re-operation

This alternative increases the potential for the DCC to benefit water quality in the south Delta while reducing potential impacts to fish relative to current conditions. Water quality is improved in the central and south Delta whenever the DCC gates are open, and this alternative would increase DCC capacity and allow year-round operation (Measures 1.1, 1.2, and 1.5). Currently, the DCC gates are closed during certain periods to protect migrating salmon from entrainment and to protect the Mokelumne River from flooding. The operational constraint caused by migrating fish can be resolved by constructing a fish screen (Measures 2.1, 2.2, 2.3, and 2.6). The Mokelumne River hydraulic constraint can be resolved by increasing downstream channel capacity. This alternative would: (1) refurbish the existing DCC gates, (2) increase the DCC diversion capacity by adding a gate on the north side of the existing facility, (3) widen the existing DCC diversion channel, (4) provide fish screens in the widened channel, (5) provide a fish bypass, and (6) dredge the North and South Forks of the Mokelumne River downstream of the DCC. A new DCC operations manual would be developed and implemented following completion of these project features.

Alternative F1 is carried forward to the IAIR analysis in Chapter 8.



Source: DWR Delta Conveyance Improvement Studies Summary Report, 2007

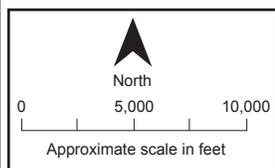


FIGURE 7-3
THROUGH DELTA FACILITY ALIGNMENT
 INITIAL ALTERNATIVES INFORMATION REPORT,
 NORTH/CENTRAL DELTA IMPROVEMENT STUDY

This page intentionally left blank.



FIGURE 7-4
AERIAL MAP OF DELTA CROSS CHANNEL
 INITIAL ALTERNATIVES INFORMATION REPORT,
 NORTH/CENTRAL DELTA IMPROVEMENT STUDY

This page intentionally left blank.



FIGURE 7-5
Delta Cross Channel Gates

Alternative F2: Delta Cross Channel Re-operation Only

Under CALFED's Preferred Program Alternative, Reclamation and DWR are evaluating improved operational procedures for the DCC to address fishery and water quality concerns. These studies are ongoing and include options such as being closed seasonally for fish migration, tidal operation, and day/night operation.

When the gates are open, water enters the Mokelumne River system through the DCC using Measures 1.2 and 1.5 to create a freshwater corridor in the central Delta.

The gates are closed seasonally (typically in fall) to protect juvenile spring- and winter-run Chinook salmon outmigrants from entrainment in the central and south Delta (Measure 2.2). However, when the gates are closed, the freshwater corridor is reduced because a portion of freshwater flows to Georgiana Slough before flowing back to the Sacramento River. More flexible gate operations could improve Delta water quality and could provide increased protection for certain fish species. Several studies have monitored the salmon runs and the hydrodynamics in the Sacramento River to understand the behavior of fish in the north and central Delta and obtain statistically significant patterns of salmon outmigration.

It is possible that the re-operation of the DCC may be a component of all alternatives and not a stand-alone alternative. This alternative is carried forward to the IAIR analysis in Chapter 8.

Management Alternatives

Several Delta export water quality improvement projects have been proposed that focus on providing improved freshwater flow from the Sacramento River toward the south Delta. Management of the Delta outflow may meet the Study objectives by providing some salinity reduction at several pumping plant locations as well as improving freshwater wetland habitat for fish and waterfowl.

Alternative G: Mokelumne River Water Exchange

This alternative would increase Sacramento River water diversions to the East Bay Municipal Utility District (EBMUD) in exchange for increased Mokelumne River flows delivered to the central and south Delta (Measure 1.2).

One option is to create a water quality exchange program through coordinated operation of the Freeport Project diversion facility and Pardee and Camanche Reservoirs. EBMUD is a CVP contractor and receives part of its water supply from the Sacramento River diversion at Freeport and a much larger portion from its Mokelumne supplies diverted at Camanche Reservoir. The proposed alternative would increase the Freeport Project diversion on the Sacramento River and would increase the release of water from Pardee and Camanche Reservoirs into the Mokelumne River and central Delta. EBMUD would essentially “exchange” a portion of their Mokelumne River supply for a comparable amount of Sacramento River water. If excess Freeport Diversion capacity exists and available storage in Pardee and Camanche Reservoirs exists, higher diversions from Freeport could be made and banked in the reservoirs. Higher releases from Pardee and Camanche Reservoirs into the lower Mokelumne River channel would improve the freshwater flow into the central Delta.

The current maximum Freeport Project diversion capacity is 185 million gallons per day (approximate 17,000 acre-feet per month), but only a portion of this capacity would be used outside of drought periods. To offset the capital cost of such a project, EBMUD is offering the opportunity for use of EBMUD capacity to other parties during non-drought periods. Analysis of the frequency of available capacity at both the diversion facility and for storage in Pardee and Camanche Reservoirs would be needed to estimate the maximum flow that could be augmented in the lower Mokelumne River. However, the coordinated operation would try to satisfy the following objectives: (1) divert the maximum allowable at Freeport during April through September, (2) deliver Freeport water to Pardee and Camanche Reservoirs and exchange a comparable amount of Mokelumne River water, (3) maintain a water quality “account” in Pardee and Camanche Reservoirs that is equal to the amount of water exchanged, (4) augment the release of water into the lower Mokelumne River by providing water from the water quality account, and (5) target water quality releases to the periods in the summer and fall of years when Delta export water quality declines.

Alternative G is carried forward to the IAIR analysis in Chapter 8.

Alternative H: Outflow Management/Sacramento River Flow Augmentation

The Outflow Management/Sacramento River Flow Augmentation Alternative (or Outflow Management Alternative) would increase Delta outflows during September of all years and other specific months under certain annual precipitation conditions, thereby reducing salinity at several Delta pumping and intake facilities (Measure 1.4).

The management alternative would be to voluntarily increase Delta outflow by 500 cfs in all months when the allowable Delta outflow is less than 4,000 cfs. This would allocate 500 cfs (1,000 acre-feet per day) for September in all year types (30 thousand acre feet [taf]). This would also allocate 500 cfs in August of dry and critical years (30 taf) and in October, November, and December of critical years (90 taf). The total allocation for salinity improvement would be 30 taf in wet, above-normal, and below-normal years; 60 taf in dry years; and 150 taf in critical years.

The expected salinity improvements are based on the idea that Jersey Point EC and subsequent Contra Costa Water District Rock Slough intake for Pumping Plant #1 (PP#1) EC and chloride—as well as Los Vaqueros, Banks Pumping Plant, and Jones Pumping Plant EC values—are dependent on the “effective Delta outflow.” The effective Delta outflow is the moving average of Delta outflow and is equivalent to a steady Delta outflow that would allow a specific amount of sea water intrusion at each location in the western Delta.

Alternative H is carried forward to the IAIR analysis in Chapter 8.

This page intentionally left blank.

Comparison of Alternatives

Introduction

This chapter discusses the technical approach and results of a comparative analysis of the seven individual NoCDIS alternatives described in Chapter 7. The technical approach includes discussion of the hydrodynamic, water quality, and fisheries analysis conducted for this project. The goal of these analyses is to rank the various alternatives with respect to the two Study objectives: improvements in water quality and fisheries conditions.

In particular, the fisheries analysis focuses on the hydrodynamic effects of the alternatives on particular in-Delta species and their different life stages. The fisheries analysis is largely qualitative, and the modeling used in the analyses should be considered screening level. Professional judgment is used to supplement the modeling results to evaluate the effects to fishery resources. The analysis does not attempt to evaluate additional stressors to fishery resources, including toxics, competition, and harvest, nor does it determine if or how any alternative may influence these factors.

For additional comparison between alternatives, cost estimates completed to date by various studies are also documented in this chapter. The cost estimates are standardized with the same contingencies and non-construction costs to provide an order-of-magnitude cost comparison.

Technical Approach

Eleven NoCDIS alternatives were described in Chapter 7, and seven alternatives were retained for technical evaluation and comparison in the IAIR due to previous screening efforts. The remaining seven NoCDIS alternatives were analyzed primarily using the DWR DSM2 model and Particle Tracking Model (PTM). DSM2 consists of two parts: DSM2 HYDRO and DSM2 QUAL. DSM2 HYDRO is a one-dimensional hydrodynamic model of the Sacramento–San Joaquin Delta. HYDRO reads user-defined time series of riverine inflows and tidally varying stages at Martinez, and calculates velocity, flow, and stage every 15 minutes throughout the model domain. The hydrodynamic results (stage and velocity) are then used in DSM2 QUAL—the water quality component model of DSM2—to predict the distribution of salinity throughout the model domain as it varies with time. The model uses EC as a surrogate for salinity; thus, results will be presented in EC units of $\mu\text{mhos/cm}$. The terms salinity and EC are both used in this report.

PTM was used to provide a relative description of fisheries impacts and benefits for the alternatives analysis. PTM uses results from the DSM2 HYDRO model to

predict the fate and transport of neutrally buoyant particles released at user-defined times and locations. The movements of the neutrally buoyant particles without consideration of fish behavior can be interpreted as predicting the movements of small, larval fish.

Cost estimates were collected from previous studies completed on several of the alternatives compiled by this report. When available, these estimates are provided as a basis for comparison with other alternatives and should be considered order-of-magnitude level.

A baseline simulation was developed to provide a point of comparison for the seven project alternatives. No additional calibration or verification exercises were performed for this Study. DSM2 has been calibrated and verified by DWR (1997). This baseline was developed with the following assumptions:

- OCAP CALSIM (2001)
- EWA simulation
- 2001 level of development

Overview of Modeling Methods

This subsection summarizes the models used to analyze the hydrodynamics, water quality, and fisheries effects of the NoCDIS alternatives.

Hydrodynamic Modeling

The hydrodynamic results serve as a foundation for the water quality and PTM (fisheries) modeling used to evaluate the performance of the alternatives with respect to the Study objectives.

Results from the DSM2 HYDRO model were analyzed at the following locations:

- Sacramento River at Freeport
- Sacramento River immediately downstream of the Delta Cross Channel and Georgiana Slough
- Sacramento River at Rio Vista
- Delta Cross Channel
- Georgiana Slough at Sacramento River
- Mouth of Mokelumne River
- Mouth of Middle River
- Mouth of Old River
- Fisherman's Cut at False River
- False River at San Joaquin River

- Three Mile Slough at Sacramento River
- Head of Old River downstream of barrier
- Old River at Clifton Court Ferry
- Old River at Highway 4
- Victoria Canal at Middle River

For each alternative, monthly average flows were generated from daily model output and compared through time-series plots and frequency analyses to the baseline simulation results. Average annual flow patterns were also developed. These patterns consisted of the average of individual months presented annually (i.e., average of all October flows into a single value representing October).

Model-predicted flows at individual locations were grouped to provide a more general view of the distribution of flows throughout the Delta for the alternatives analyses. For example, flows in the vicinity of the DCC were grouped as either Cross-Delta flows (inclusive of DCC, Georgiana Slough, and Through-Delta Diversion as appropriate) or flows remaining in the Sacramento side of the system (inclusive of Sacramento River, Sutter Slough, and Steamboat Slough). Additional flow groupings included flow from the north Delta into the San Joaquin River (from Mokelumne River, Little Potato Slough, Little Connection Slough, and Potato Slough) and flow from the San Joaquin River into the south Delta (through Old River, Middle River, Turner Cut, False River, Fisherman's Cut, and Dutch Slough).

Water Quality Modeling

Results from the DSM2 QUAL model were analyzed in a similar fashion as the HYDRO results. For each alternative, monthly average EC values were generated from daily model output and compared through time-series plots and frequency analyses to the baseline simulation results. Average annual EC patterns were also developed. These patterns consisted of the average of individual months presented annually (i.e., average of all October EC values into a single value representing October). Output at select locations was analyzed with time series plots, frequency distributions, and period averages. Model-predicted EC was obtained at the following locations:

- Sacramento River at Rio Vista
- Sacramento River at Emmaton
- Sacramento River at Collinsville
- San Joaquin River at Antioch
- San Joaquin River at Jersey Point
- Rock Slough at Contra Costa Canal
- Old River at Bacon Island
- Old River at Highway 4
- Clifton Court (Banks Pumping Plant)
- Jones Pumping Plant

To provide a general overview of relative water quality changes (percent change in EC from the baseline) for each alternative, results from the 16-year DSM2 planning study representing hydraulic conditions from water year 1975 through 1991 were averaged on a monthly, annual, and full period basis. Different periods were analyzed because the relative performance of various alternatives may be different on shorter time scales. Furthermore, since the proposed changes in operation for the individual alternatives vary seasonally and annually, there are frequently no differences between the baseline condition and the alternative condition. Thus, averaging over the full 16-year period can reduce the bias of certain alternatives that may target conditions only in select months.

Particle Tracking Modeling

Simulation runs using the PTM were conducted for each alternative using DSM2 HYDRO results. PTM was used to evaluate each alternative with respect to fish protection and enhancement, a second objective of this Study. It is important to note that for this IAIR stage of the planning process, the alternatives were operated in the modeling analyses to achieve water quality improvements and simulated operations were not optimized for fishery benefits.

The PTM results were used to determine the likely pattern of fish movement with a given alternative, and biological research results were applied to determine if the resulting pattern would be positive or negative for fish. PTM results were considered positive for fish if entrainment was reduced at the Delta export facilities; results were considered negative if entrainment was increased at the export facilities.

Kimmerer and Nobriga (2008) concluded that DSM2 and PTM are likely suitable for describing Delta-wide fish movements, given the extent that fish allow themselves to be dispersed by tidal and river currents, similar to the behavior of waterborne particles. These scientists also concluded that the PTM results may provide information about salmon migrating in channels. Because salmon are subject to tidal patterns and currents as they migrate, they become distributed among alternative pathways. Since salmon are unlikely able to distinguish pathways, they will disperse themselves in a pattern similar to that of particles subject to the same tidal currents.

Animations of PTM results were used to visualize differences in the fate and transport of particles released at various locations in the Delta. Simulations were made with particle releases at the following locations:

- San Joaquin near Antioch, downstream of Dutch Slough (DSM2 Node 461)
- Mokelumne River just upstream of the San Joaquin River, downstream of Georgiana Slough (DSM2 Node 272)
- Sacramento River upstream of Hood (DSM2 Node 337)
- San Joaquin River at Fourteen Mile Slough, Upstream of Turner Cut (DSM2 Node 24)

These points were chosen because they represent typical and critical locations from which fisheries benefits can be evaluated for a given species of concern. The applicable species and rationale for each release point is summarized in Table 8-1. Additional details are provided in the following text.

TABLE 8-1
PTM Particle Insertion Points, Applicable Species, and Rationale

Insertion Point	Applicable Species	Rationale
San Joaquin River near Antioch, downstream of Dutch Slough	Delta smelt, longfin smelt	Evaluates whether fish are entrained at the export facilities
Mokelumne River upstream of San Joaquin River, downstream of Georgiana Slough	Sacramento River Chinook salmon, steelhead, sturgeon, Delta smelt, splittail, and Mokelumne River fall-run Chinook salmon	Evaluates the duration of presence of juvenile salmonids in the central Delta and whether fish are entrained at the export facilities
Sacramento River, upstream of Hood	All Sacramento River Chinook salmon, steelhead, sturgeon, Delta smelt, and splittail	Evaluates whether fish remain in the Sacramento River system or become entrained into the central Delta
San Joaquin River at Fourteen Mile Slough, upstream of Turner Cut	San Joaquin River fall-run Chinook salmon, steelhead, splittail, Delta smelt, longfin smelt	Evaluates whether fish move west through the Delta or to channels south of the San Joaquin River

PTM Release Point at Sacramento River, Upstream of Hood

As described in Table 8-1, the movement of particles released from Hood can be used to determine the percentage of Sacramento River fish upstream of this point that would remain in the Sacramento River system under a given alternative or move into the central Delta. Biologists have established that it is preferable for fish (e.g., Chinook salmon, steelhead) to remain in the Sacramento River rather than being diverted into the central Delta. Fish are exposed to fewer predators and have a shorter residence time (less time exposed to predators, poor habitat conditions, or other negative factors) if they remain in the Sacramento River. In the central Delta, fish have a longer duration of exposure to in-Delta diversions and predators, poorer water quality, and they have a greater potential for entrainment at the export facilities. PTM runs cannot simulate and account for the potential fish losses due to predation or other mortality factors related to delays within the central Delta, but it has generally been accepted that reducing fish diversion from the lower Sacramento River into the central Delta provides for higher survival rates. Several studies have supported this hypothesis:

- Studies using coded wire-tagged fry- and smolt-sized Chinook salmon have demonstrated that fish survival is lower in the central Delta relative to the north Delta. Young salmon diverted into the central Delta via the DCC or Georgiana Slough have reduced survival compared to fish remaining in the Sacramento River downstream of those points in both winter and spring (Brandes and McLain, 2001).

- Studies conducted by releasing radio-tagged juvenile Chinook salmon in northern Georgiana Slough and in the lower Sacramento River downstream of Georgiana Slough found a higher rate of fish mortality in Georgiana Slough compared to those remaining in the Sacramento River. The difference was attributed to up to four times greater predation losses on radio-tagged salmon in Georgiana Slough compared to those fish migrating down the lower Sacramento River (Vogel, 2004).
- More recent research in the north Delta found that acoustic-tagged juvenile salmon were diverted into Sutter and Steamboat Sloughs in relatively high proportions when the DCC gates were both open and closed (26 percent and 37 percent, respectively) (Vogel, 2008). The fate of fish using those north Delta migration corridors will be evaluated during winter 2008 to 2009.

The alternatives described in this report were therefore evaluated positively for fish enhancement if a greater percentage of the tracked particles originating in the Sacramento River upstream of Hood remained in the Sacramento River rather than moving toward the central Delta.

PTM Release Point at San Joaquin River at Fourteen Mile Slough

Research conducted on juvenile salmon migration in the lower San Joaquin River found that radio-tagged fish released adjacent to Fourteen Mile Slough were diverted in relatively high numbers into channels south of the San Joaquin River (e.g., Turner Cut). Once the fish entered those channels, the salmon generally did not return back to the main San Joaquin River channel (Vogel, 2004).

All alternatives were therefore evaluated positively for fish if a greater percentage of the tracked particles originating at Fourteen Mile Slough remained in the San Joaquin River (or if fewer of the particles were diverted to south channels when compared to the baseline condition).

PTM Release Point in Mokelumne River, Downstream of Georgiana Slough

This release point is useful in determining the transport and fate of any fish that may have been spawned in the north-central Delta, or may have been transported into the lower Mokelumne River from the Sacramento River via the Delta-Cross Channel, Georgiana Slough, or from the Mokelumne River itself. Brandes and McLain (2001) reported that ocean recovery rates for coded wired-tagged Chinook salmon fry released during drier years in the north Delta (Sacramento River at Courtland, Ryde, or Isleton) were greater than those released in the Central Delta (at the mouth of the Mokelumne River or in the North and South Forks of the Mokelumne Rivers).

All alternatives were evaluated positively for fish if a greater percentage of the tracked particles originating at the Lower Mokelumne River insertion point remained in the San Joaquin River (or if fewer of the particles were diverted to south channels and, ultimately, the export facilities in the south Delta when compared to the baseline condition).

PTM Release Point in the San Joaquin River near Antioch, Downstream of Dutch Slough

Selection of this release point is useful in determining the transport and fate of species (Delta and longfin smelts) that may have been migrated from the western Delta into, or were spawned within, the lowermost reaches of the San Joaquin River. From the IEP 20-millimeter larval fish survey database, large numbers of both Delta and longfin smelt have been historically captured from monitoring locations near this PTM release point.

All alternatives were evaluated positively for fish if a greater percentage of the tracked particles originating at the Lower San Joaquin River insertion point (downstream of Dutch Slough) remained in the San Joaquin River (or if fewer of the particles were diverted to south channels and ultimately the export facilities in the south Delta) when compared to the baseline condition.

Life Stage Periodicity

The temporal presence of the fish species and life stages of those species evaluated are shown in Table 8-2. In this table, only those life stages that may directly be affected by changing hydrology within the Study area are shown. In some cases (e.g., adult green sturgeon), insufficient detailed information may preclude the evaluation of a species or life stage. In Table 8-2, the monthly presence of a species' life stage (adult, juvenile, etc.) is categorized for each month. Their presence in the north-central Delta by month is described as either absent, minor, significant, or a primary month of presence.

PTM Run Time Periods

As shown in Table 8-3, model simulations were conducted for several time periods representing average to below-average river inflows and during seasonal periods, reflecting the potential presence of the fish species of interest. Model periods were also chosen to maintain consistency with other ongoing Delta studies, such as the BDCP. Model simulations were run for 120 days, with 1,000 particles released evenly over a 5-day period at the beginning of each simulation.

Since some alternatives are not continually operated, it is possible that the PTM periods correspond to times when there is no difference in operation between the baseline and an alternative. For example, the False River Gates were not operated during spring 1983 because of elevated river flows, so PTM simulation of this period would show no difference from the baseline.

Chapter 8: Comparison of Alternatives

TABLE 8-2
Life Stage Periodicity of Fishes Evaluated in the Comparison of Alternatives

Species (References)	Life Stages	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Delta smelt ^{a,b,c}	Adult migration	S	P	P	P	M							M
	Adult spawning		S	P	P	M							
	Embryo incubation		S	P	P	M							
	Juvenile rearing (< 20 mm)		M	P	P	S	M						
	Juvenile rearing (> 20 mm)			M	P	P	S						
Chinook salmonid ^e	Juvenile winter-run	P	P	P								P	P
	Juvenile spring-run	P	P	P	P							P	P
	Juvenile fall-run		P	P	P	P	P						
	Juvenile late-fall run	P	P	P	P	P						P	P
Steelhead ^e	Juvenile	P	P	P	P	P							P
Green sturgeon ^{f,g,h}	Rearing (> 10 months, < 3 years)	P	P	P	P	P	P	P	P	P	P	P	P
Sacramento splittail ^a	Adult migration	P	P	P	P	P	P						S
	Adult spawning		S	P	P	S	S	S					
	Embryo incubation		S	P	P	P	S	S					
	Larval rearing		S	P	P	P	P	S					
	Juvenile rearing		M	P	P	P	P	P	S				
Longfin smelt ^{a,c,i}	Adult migration	P	P	P	M							M	S
	Adult spawning	S	P	P	S	M							M
	Embryo incubation	S	P	P	P	S	M						
	Larval rearing (< 20 mm)	M	S	P	P	S	M						
	Juvenile rearing (> 20 mm)		M	S	P	P	P	S					

Key:

M = minor presence (light gray)
S = significant presence (dark gray)
P = primary presence (black)

Notes:

- ^a Moyle, 2002
- ^b Bay Institute, 2007
- ^c Moyle et al., 1992
- ^d Vogel, pers. comm..
- ^e Triennial Review, Bay Institute, Art Bagget Exhibit, 2005
- ^f McLain. pers. comm. 2006
- ^g Kelley et al., 2006
- ^h IEP Database
- ⁱ Fish and Game Commission, 2008

TABLE 8-3
Summary of PTM Run Periods

Run Time ID	Start Date	Sacramento River Flow Exceedance*
T1	03/01/90	90%
T2	02/01/76	90%
T3	02/01/87	75%
T4	02/01/84	50%
T5	04/01/76	90%
T6	04/01/81	75%
T7	04/01/79	50%

* Exceedance based on 3-month average of Sacramento River flow from the start date.

Table 8-4 summarizes the number of months out of the 4-month PTM runs in which there were changes in operation for each alternative.

TABLE 8-4
PTM Run Periods and Frequency of Operational Changes in NoCDIS Alternatives

Run	Period	Alt A West False River Gates	Alt D Three Mile Slough Gates	Alt E1 Through- Delta Facility (Original)	Alt F1 DCC Modification and Re-operation	Alt F2 DCC Re-operation Only	Alt G Mokelumne River Water Exchange	Alt H Outflow Management
T1	Mar-90	4	2	4	4	4	2	0
T2	Feb-76	4	3	4	4	4	2	0
T3	Feb-87	3	2	4	4	4	2	0
T4	Feb-84	0	0	2	2	2	2	0
T5	Apr-76	4	3	4	4	4	3	0
T6	Apr-81	3	1	4	4	4	3	0
T7	Apr-79	2	1	2	4	4	3	0

Note that the Outflow Management/Sacramento River Flow Augmentation Alternative and the Mokelumne River Water Exchange Alternative were not carried forward in this PTM analysis since the analysis was targeted at larval and juvenile fish species present in the spring, and the changes from these final two alternatives are focused in later months.

Capture Estimates (Baseline Conditions)

The estimated capture of particles (a surrogate for larval and juvenile fish) for the baseline condition produced the results shown in Table 8-5. The results reflect conservative assumptions for capture rates in that the flows on the Sacramento River during the PTM simulations are expected to be exceeded approximately 90 percent of the time. The approximate capture estimated for the particles inserted at Fourteen Mile Slough on the San Joaquin River is rather high, ranging

from approximately 67 to 94 percent. For particles originating in the lower Mokelumne River upstream of the San Joaquin River confluence, estimated particle entrainment at the Delta export facilities is also very high, ranging from approximately 41 to 83 percent. Moderately high entrainment is also indicated for those particles inserted upstream of Hood on the Sacramento River. PTM results for particles inserted into the lower San Joaquin River downstream of Dutch Slough indicate low to moderate entrainment (from approximately 8 to 24 percent) at the Delta export facilities.

TABLE 8-5
Capture at Export Pumps for Baseline Condition (in percent capture)

Period	San Joaquin River near Antioch, downstream of Dutch Slough	Mokelumne River, downstream of Georgiana Slough	Sacramento River upstream of Hood	San Joaquin River at Fourteen Mile Slough
Mar-90	7.7	59.9	25.6	82.1
Feb-76	23.6	83.2	38.3	93.6
Apr-76	8	40.9	18.9	66.7

Overall, for the baseline condition, the PTM results indicate a high likelihood for fish entrainment for fish originating at Fourteen Mile Slough, the Mokelumne River, and the Sacramento River; and low to moderate fish entrainment potential for fish originating at the Lower San Joaquin River (near Dutch Slough).

Results Evaluation Methodology

PTM model results were evaluated for each alternative with respect to percent-capture at the export facilities. Results were evaluated using both percent-capture of particles released and percent-reduction in capture from the baseline condition.

Alternatives Evaluation

The seven individual NoCDIS alternatives are discussed in detail as follows. Information on the components of the alternative is provided, including a summary of any operational changes associated with the simulation. A discussion of hydraulic changes in the Delta, water quality effects, and fish effects is included for each alternative. Cost estimates were compiled using information available from previous studies. Detail on the information in the cost estimates is provided later in the discussion.

Alternative A: Operable Gates on West False River

Alternative A includes installation of operable gates in West False River between Franks Tract and the San Joaquin River. The gates are operated tidally and seasonally with the intention of limiting the transport of salt to the central and

south Delta. The gates are also intended to prevent saltwater from entering Franks Tract during the flood tide and becoming trapped and mixed in Franks Tract.

Operations and Hydrodynamics

The gates are closed for approximately 12 hours per day. In this alternative, the gate position is specified in DSM2 at 15-minute intervals to simulate the gate operation tidally. Gates are left open during high river flow periods when transport of salinity into the central Delta is not a concern. The operation of the gates do not have a specific high flow trigger, but operation is based on salinity levels at Jersey Point. A summary of the monthly average gate position is represented in Table 8-6. A value of 1.0 (gray cells) would indicate that gates are open throughout the month. A value of 0.5 would indicate that the gate is open for 50 percent of the month (open 12 hours per day on average for that month) and closed for 50 percent of the month. On average, the gates are in the open position for 72 percent of the 16-year simulation. If the 57 months in which the gate remains open for the entire month are removed from consideration, the average monthly percent time the gates are open is reduced to 61 percent.

TABLE 8-6
Summary of Average Fraction of Time Gate is Open for the West False River Alternative (Open = 1.00)

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975	0.81	0.53	0.54	0.54	0.96	1.00	1.00	1.00	1.00	0.69	0.56	0.58
1976	0.57	0.53	0.52	0.54	0.53	0.55	0.55	0.56	0.57	0.57	0.56	0.58
1977	0.59	0.53	0.55	0.55	0.54	0.57	0.54	0.55	0.56	0.57	0.56	0.58
1978	0.59	0.55	0.52	1.00	1.00	1.00	1.00	1.00	1.00	0.63	0.56	0.58
1979	0.56	0.54	0.53	0.99	1.00	1.00	1.00	1.00	0.88	0.54	0.55	0.58
1980	0.59	0.53	0.53	1.00	1.00	1.00	1.00	1.00	0.96	0.62	0.55	0.58
1981	0.58	0.55	0.54	0.97	1.00	1.00	1.00	0.86	0.56	0.55	0.57	0.57
1982	0.59	0.88	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.76	0.56	0.84
1983	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1984	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.80	0.58	0.57	0.58
1985	0.59	0.88	0.89	0.57	0.54	0.58	0.68	0.90	0.57	0.56	0.57	0.58
1986	0.59	0.56	0.54	0.80	1.00	1.00	1.00	1.00	0.87	0.57	0.57	0.59
1987	0.58	0.55	0.54	0.55	0.78	1.00	0.94	0.71	0.59	0.57	0.56	0.59
1988	0.59	0.55	0.53	0.81	0.76	0.60	0.55	0.55	0.56	0.57	0.58	0.58
1989	0.60	0.54	0.55	0.55	0.55	1.00	1.00	0.91	0.57	0.56	0.57	0.58
1990	0.59	0.55	0.53	0.57	0.54	0.56	0.57	0.56	0.57	0.57	0.59	0.60
1991	0.58	0.55	0.54	0.56	0.55	0.78	1.00	0.72	0.58	0.58	0.57	0.60

Note: Months with gate open throughout the month are shaded gray.

The operable gates increase net flows to the west in False River by an average of 12 percent from the baseline simulation. This increase in flow comes from the

San Joaquin River through both the mouth of Old River and through Fisherman’s Cut. The net exchange between the Sacramento and San Joaquin Rivers through Three Mile Slough is also influenced by this alternative; net flows from the Sacramento River to the San Joaquin River through Three Mile Slough increase 7 percent from the baseline simulation.

Water Quality Improvements (Objective 1)

The False River gate is operated most consistently between the months of July through November; therefore, variations in water quality from the baseline simulation are expected to be greatest during these months. Figure 8-1 compares the average monthly change in EC from the baseline simulation at locations throughout the Delta. Changes are expressed in percentages; negative values indicate a reduction in salinity (improvement in water quality). Of the stations analyzed, Old River at Rock Slough shows the largest improvement in water quality with the West False River Gate Alternative. Average reductions in salinity between 11 and 14 percent are seen from July through December.

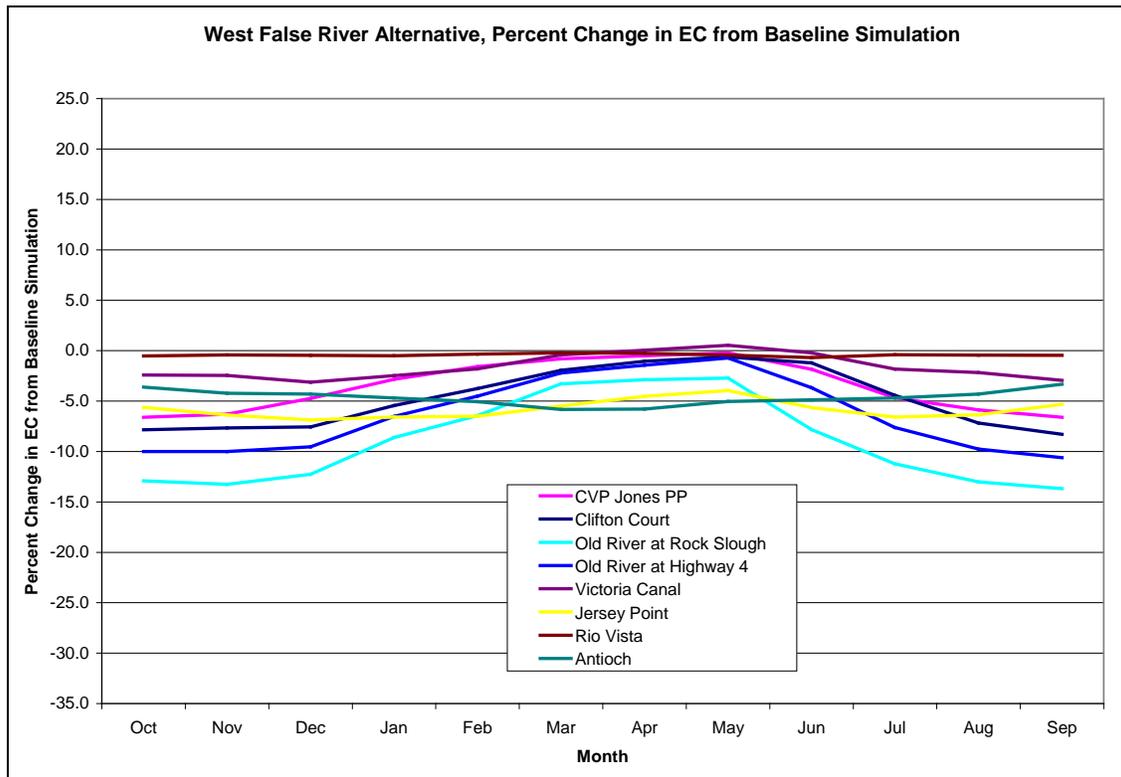


FIGURE 8-1
Comparison of Change in Monthly Average EC from Baseline Simulation for West False River Alternative

Fisheries Improvements (Objective 2)

This alternative is primarily operated for water quality control. Since the False River Gate would be operated most consistently between the months of July and November, this alternative would be expected to have minimal impacts on larval and juvenile fish species because these are months during which their presence is

expected to be low within the north and central Delta (Table 8-2). Gate operations for this alternative follow a tidal cycle. Gates are closed for approximately 12 consecutive hours, through one tidal cycle (a flood and an ebb tide). Although this creates a greater potential of salt dispersion (and therefore a positive effect on water quality), this likely has minimal benefits for the species of concern.

PTM results show only small differences between this alternative and the baseline simulation as shown in Table 8-7. Effects are slightly positive for fish originating in the Sacramento River system, varying between approximately 2 and 13 percent reduction in entrainment. Effects on fish originating in the Mokelumne River system downstream of Georgiana Slough and at Fourteen Mile Slough are mixed, but changes in entrainment are extremely small as a percentage compared to the baseline. The results of the PTM analysis for particles originating at the San Joaquin River at Fourteen Mile Slough indicated little, if any, measurable changes in entrainment as compared to the baseline for this alternative.

Particles originating on the San Joaquin River near Dutch Slough show small but beneficial reductions in entrainment (between approximately 14 percent and 29 percent) at the export facilities from the baseline scenario.

Generally, for this alternative, the effects on fish are difficult to discern, but the PTM analysis suggests there are small but positive effects. Delta and longfin smelt in the lower San Joaquin River, and possibly all species originating in the Sacramento River upstream of Hood, may benefit from this alternative. The benefits, as measured by reducing larval take at the export facilities, are shown in Table 8-7. Additional analysis with higher-resolution PTM runs would be necessary to further examine and evaluate the extent of any positive effects on fish for this alternative. Additional analysis is also needed to determine if fish benefits would be higher if the gates were operated primarily to benefit fish rather than to provide water quality improvements.

TABLE 8-7
Capture at Export Pumps for Alternative A (Operable Gates on West False River)

Period	Capture	San Joaquin River near Antioch, downstream of Dutch Slough	Mokelumne River, downstream of Georgiana Slough	Sacramento River upstream of Hood	San Joaquin River at Fourteen Mile Slough
Mar-90	% Capture	5.5	57.1	22.4	82.5
	% Decrease from Baseline	28.6	4.7	12.5	-0.5
Feb-76	% Capture	20.2	84.7	37.5	94.1
	% Decrease from Baseline	14.4	-1.8	2.1	-0.5

TABLE 8-7
Capture at Export Pumps for Alternative A (Operable Gates on West False River)

Period	Capture	San Joaquin River near Antioch, downstream of Dutch Slough	Mokelumne River, downstream of Georgiana Slough	Sacramento River upstream of Hood	San Joaquin River at Fourteen Mile Slough
Apr-76	% Capture	6.1	41.7	17	62.8
	% Decrease from Baseline	23.8	-2.0	10.1	5.8

Cost Estimate

Several cost estimates have been developed for this alternative by previous studies:

- The DWR Flooded Islands Pre-feasibility Study (Moffatt & Nichol, 2006) estimated the capital cost of this alternative to be approximately \$21 million. This estimate included fabrication and installation of an 828-foot-long gate, sheetpile walls at marginal closure areas, site preparation (including dredging and rock placement), and control structures (building, security, telemetry, and navigation aids). A 40-percent contingency cost and 25-percent engineering, legal, and administration cost were also included.
- The Franks Tract Value Engineering Study (DWR, 2007a) estimated this alternative to be approximately \$63 million. The estimate included cost of gate construction and boat passage, but did not include cost of design, permits, or construction management.

Alternative D: Operable Gates on Three Mile Slough

The Operable Gates on Three Mile Slough Alternative involves installation of an operable gate in Three Mile Slough. The gates would be closed on a portion of the ebb tide to reduce San Joaquin River water from entering the Sacramento River. This action serves to keep flow in the San Joaquin River and increases the net westerly flow past Jersey Point (known as QWEST).

Operations and Hydrodynamics

The gate closure is a function of river flows, exports, and tidal flows. The duration of closure was specified to balance the outflows between the Sacramento River and the San Joaquin River. In DSM2, the closure is represented by setting the weir coefficient for flow in the downstream direction (San Joaquin River to Sacramento River) equal to zero. The coefficient for unimpeded flow is equal to 8.0. The coefficients in between were set to achieve a desired flow magnitude in an iterative manner. In the Three Mile Slough Alternative, the downstream weir coefficients were set monthly. Table 8-8 summarizes these coefficients.

The operation of the gate on Three Mile Slough significantly alters the flow exchange between the Sacramento and San Joaquin Rivers through Three Mile Slough. Net flows through Three Mile Slough in the baseline simulation average 1,400 cfs from the Sacramento River to the San Joaquin River. These net flows, while still small compared to peak tidal flows on the order of 30,000 cfs, increase to 2,900 cfs in Alternative D. The operation of the gate during ebb tide in Three Mile Slough reduced the loss of water from the San Joaquin River to the Sacramento River on ebb tide, thus increasing the net downstream flow in the San Joaquin River. Net westerly flows in False River also increase slightly in this alternative (6 percent increase from the baseline).

TABLE 8-8
Alternative D Operable Gates on Three Mile Slough – Downstream Weir Flow Coefficient (8.00 = unimpeded flow)

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	0.53	0.44
1976	0.70	0.45	0.42	0.49	0.49	0.48	1.20	8.00	1.47	0.98	0.93	0.91
1977	8.00	1.13	1.69	8.00	0.77	8.00	1.58	8.00	8.00	3.21	1.10	8.00
1978	8.00	8.00	0.47	8.00	8.00	8.00	8.00	8.00	8.00	8.00	0.60	0.71
1979	1.14	1.09	1.03	0.19	8.00	8.00	8.00	8.00	8.00	0.35	0.52	1.00
1980	1.20	0.59	0.27	8.00	8.00	8.00	8.00	8.00	8.00	8.00	0.54	0.69
1981	1.37	1.22	0.60	0.21	0.10	0.10	8.00	8.00	8.00	0.39	0.56	0.77
1982	1.00	0.10	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	0.62	0.52
1983	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
1984	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	0.63	0.84
1985	0.73	0.10	0.24	0.44	0.27	0.53	8.00	8.00	8.00	0.36	0.54	0.61
1986	0.89	0.87	0.35	0.16	8.00	8.00	8.00	8.00	8.00	0.45	0.46	0.64
1987	1.04	1.15	0.91	0.55	0.28	0.17	8.00	8.00	1.51	0.62	0.76	0.93
1988	5.42	1.14	0.39	0.10	0.35	1.44	1.10	1.48	8.00	1.05	8.00	2.23
1989	5.42	1.36	0.90	0.68	1.08	0.10	0.22	0.74	1.08	0.50	0.73	0.69
1990	0.73	0.90	0.53	0.22	0.28	0.63	1.07	8.00	8.00	8.00	1.71	8.00
1991	8.00	8.00	8.00	8.00	2.64	0.10	0.81	1.46	8.00	8.00	0.82	8.00

Note: Months with unimpeded flow are shaded gray.

Water Quality Improvements (Objective 1)

The Three Mile Slough gate is mainly operated during the months of August through December; therefore, improvements in water quality in the south Delta compared to the baseline are expected to peak during this period. Figure 8-2 presents a comparison of the percent change in EC from the baseline simulation for eight locations throughout the Delta. The largest improvements in water

quality for the Three Mile Slough Alternative are seen at Jersey Point on the San Joaquin River adjacent to Three Mile Slough. Average monthly improvements for the planning period peak in January (32 percent) and are minimal in May and June. Changes are more pronounced in Old River (Highway 4, Rock Slough) than at the export facilities. Annual average improvements in salinity at the export pumps are 5.3 percent at the CVP Jones Pumping Plant and 7.7 percent at the Banks Pumping Plant (Clifton Court).

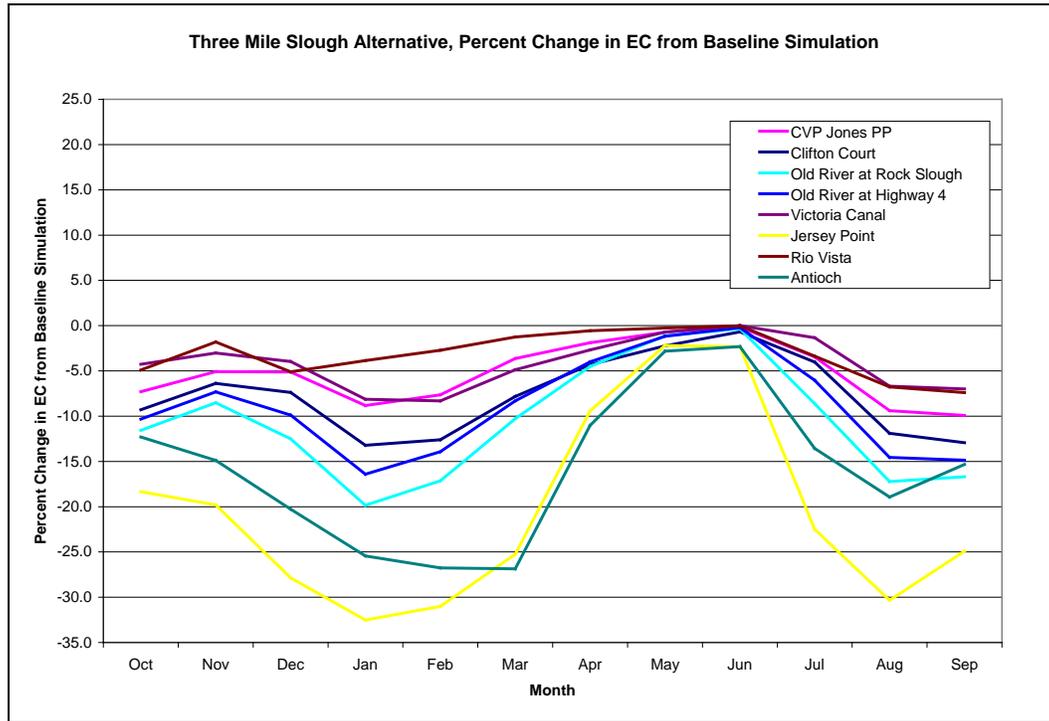


FIGURE 8-2
Three Mile Slough Alternative, Percent Change in EC from Baseline Simulation

Fisheries Improvements (Objective 2)

For this alternative, PTM results show a significant benefit to particles released in the lower San Joaquin River at Dutch Slough during the periods with the highest take in the baseline scenario. Reductions in the percentage entrainment are approximately 21 percent to 69 percent from the baseline condition for particles inserted near Dutch Slough, as shown in Table 8-9. While the absolute capture percentages for the three simulation runs are low for both baseline (8 to 24 percent) and the Three Mile Slough Alternative (4 to 9 percent) for particles from this insertion point, this alternative would likely be beneficial for Delta and longfin smelts originating from this location. There are only very small changes in PTM results for the other release points analyzed; therefore, little benefit would be expected from this alternative for fish in those areas.

The Three Mile Slough Gate is operated most often in the months of August through December, a period of low occurrence for the fish species of interest (Table 8-2). However, overall the PTM results show that the Operable Gates on

Three Mile Slough Alternative could significantly benefit Delta and longfin smelts, especially those located in the lower San Joaquin River. Any benefits as predicted by the PTM model analyses are approximately twice that of the Operable Gates on the West False River Alternative. Similar to the West False River Alternative analysis, this PTM analysis was based on the gates operating for water quality purposes. Additional analysis is needed to determine if fish benefits would be higher if the gates were operated primarily to benefit fish, especially in the January to May timeframe.

TABLE 8-9
Capture at Export Pumps for Alternative D (Operable Gates on Three Mile Slough)

Period	Capture	San Joaquin River near Antioch, downstream of Dutch Slough	Mokelumne River, downstream of Georgiana Slough	Sacramento River upstream of Hood	San Joaquin River at Fourteen Mile Slough
Mar-90	% Capture	4.1	58.6	25	81.6
	% Decrease from Baseline	46.8	2.2	2.3	0.6
Feb-76	% Capture	9	79	41.1	94.5
	% Decrease from Baseline	61.9	5.0	-7.3	-1.0
Apr-76	% Capture	6.3	42.6	17.1	60.7
	% Decrease from Baseline	21.3	-4.2	9.5	9.0

Cost Estimate

The Franks Tract Value Engineering Study (DWR, 2007a) estimated the construction cost of this alternative at approximately \$43 million. This does not include the cost of design, permits, or construction management.

Alternative E1: Through-Delta Facility

The TDF Alternative evaluates a simulated diversion from the Sacramento River near Hood to the South Fork of the Mokelumne below the Delta Cross Channel.

Operations and Hydrodynamics

The diversion is capped at 4,000 cfs, and is reduced as necessary to maintain minimum flow requirements in the Sacramento River at Rio Vista. Flows are also curtailed or stopped during periods of high river flow when the additional transfer would not have a meaningful influence on water quality in the south Delta. The monthly average flow through the diversion for the 16-year simulation period is presented in Figure 8-3, which also provides the average flows for each month of the simulation.

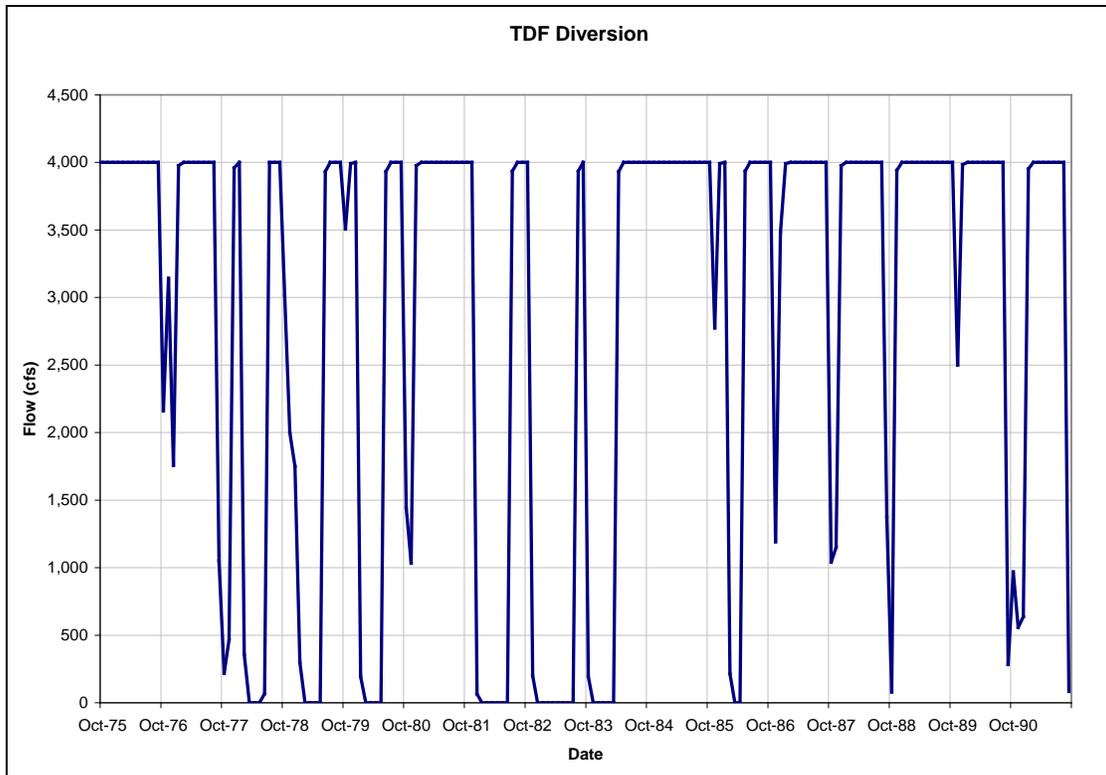


FIGURE 8-3
Monthly Average Flow into Through-Delta Facility

The TDF Alternative removes water from the Sacramento River near Hood and transfers the water to the Mokelumne River. The flow through the DCC is reduced by this alternative due to the decrease in the hydraulic gradient from the Sacramento River to the Mokelumne. This decrease occurs because of the additional water delivered to the Mokelumne by the Hood diversion. Decreases in DCC flow average approximately 40 percent annually, with peak decreases in the summer months. Net flows from the Sacramento River to the San Joaquin River through Three Mile Slough also decrease in this alternative (27 percent reduction from the baseline) because of the decrease in the average hydraulic gradient from west to east.

Water Quality Improvements (Objective 1)

Peak flows in the TDF occur in the months of July and August and; therefore, improvements in south Delta water quality are expected during these months. Figure 8-4 presents a comparison of the monthly average change in EC from the baseline simulation for eight locations in the Delta. Model results demonstrate that, in addition to improvements in water quality in late summer, there are also considerable improvements in the winter months. Peak improvements (30 percent decrease in salinity) are seen at Jersey Point in February. At the export facilities, average monthly improvements range from 2 percent in May to 16 percent in September at the Jones Pumping Plant, and from 5 percent in May to 21 percent in September at Clifton Court.

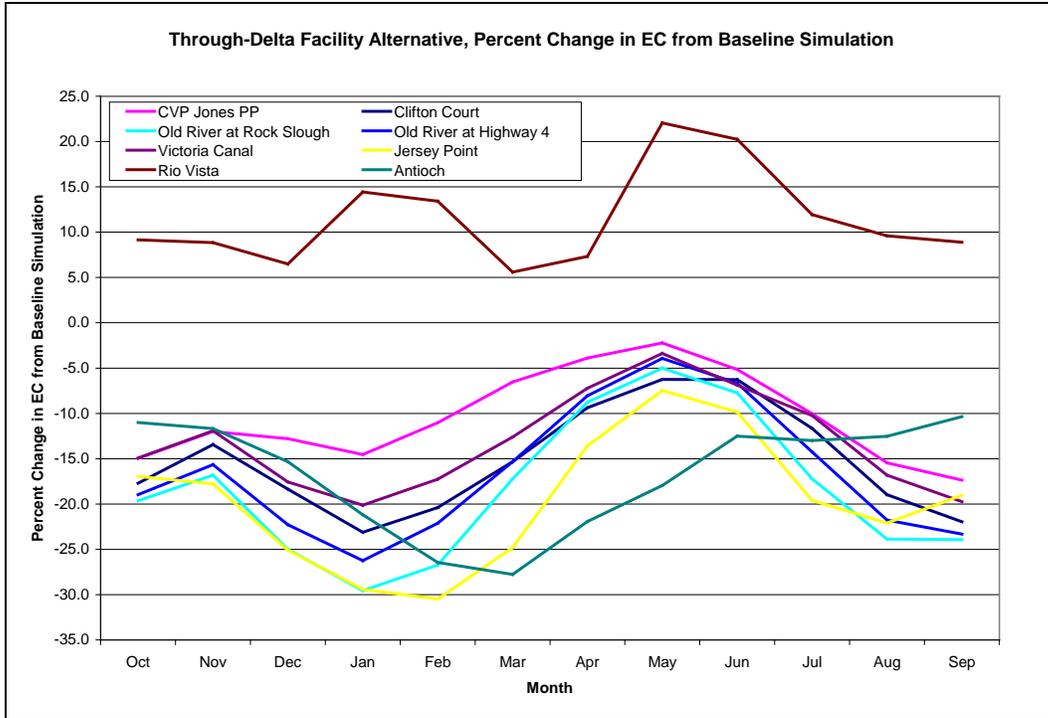


FIGURE 8-4

Comparison of Change in Monthly Average EC from Baseline Simulation for Through-Delta Facility Alternative

Figure 8-4 presents the average annual pattern of changes in monthly salinity between the TDF Alternative and the baseline simulation. The change is expressed as a percentage, calculated by averaging all monthly salinity values for each alternative and then calculating the percentage. The results at Rio Vista are provided to demonstrate that while EC is reduced in the south and central Delta by operating the TDF, EC increases on the Sacramento River as expected.

Table 8-10 provides a more detailed look at the influences of the TDF Alternative at CVP Jones Pumping Plant by providing the percent change in salinity for each individual month. Statistics at the bottom of Table 8-10 provide monthly average, maximum, and minimum values. The average values presented in Table 8-10 will be slightly different than the averages presented in Figure 8-4 because the average in Table 8-10 is of individual monthly changes, while the averages in the figure present the average change calculated from the period average, not the monthly average. The averages presented in Figure 8-4 do not reflect the wide variation between the average monthly change and the maximum and minimum monthly changes. For example, the average decrease in salinity at Jones Pumping Plant during October is 13.5 percent, while the largest decrease is almost double (24.3 percent). The period averages presented in Figure 8-4 include times when the facility was not in operation; therefore, the averages are not fully representative of the facility during periods of operation.

TABLE 8-10
Monthly Percent Change in EC at Jones Pumping Plant for the Through-Delta Facility Alternative

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1976	-6.4	-5.1	-17.6	-26.4	-28.2	-19.7	-11.4	-6.2	-11.5	-13.1	-9.4	-17.7
1977	-16.4	-12.4	-9.8	-8.3	-7.5	-5.7	-9.6	-8.3	-12.4	-15.7	-14.3	-12.9
1978	-8.2	-5.0	-11.7	-15.4	-1.6	-0.4	0.0	0.0	0.0	-1.4	-11.0	-18.2
1979	-16.7	-13.2	-12.2	-8.6	-1.1	0.0	0.2	0.0	-0.2	-7.0	-19.9	-21.2
1980	-18.8	-17.8	-17.6	-5.1	0.0	-0.2	0.0	0.0	-0.1	-1.7	-10.6	-16.6
1981	-12.8	-7.8	-13.5	-15.9	-9.7	-2.6	-0.5	-0.3	-5.0	-21.9	-27.3	-24.8
1982	-21.1	-19.7	-3.5	-0.4	-0.4	-0.1	0.0	0.0	0.0	-0.3	-6.7	-8.6
1983	-0.5	-0.2	-0.1	-0.3	-0.4	0.5	0.0	-0.1	-0.2	0.1	-0.2	0.0
1984	0.0	0.0	0.1	-0.1	0.0	0.3	0.2	-0.1	-2.1	-1.8	-6.0	-17.4
1985	-20.5	-26.0	-7.1	-3.4	-13.9	-9.6	-4.1	-1.5	-4.5	-20.1	-26.6	-25.4
1986	-22.2	-14.3	-17.1	-12.4	-1.0	0.4	-0.1	0.0	-0.3	-2.3	-11.2	-16.8
1987	-17.6	-14.1	-12.7	-12.2	-12.3	-5.0	-2.6	-0.3	-5.2	-11.0	-17.8	-22.2
1988	-17.6	-9.1	-17.6	-26.2	-10.6	-1.0	-2.7	-3.3	-8.0	-9.2	-15.3	-10.4
1989	-6.4	-7.6	-15.2	-23.6	-13.7	-10.2	-2.0	0.4	-2.9	-15.3	-24.1	-24.3
1990	-24.3	-19.5	-22.2	-33.3	-28.5	-12.2	-6.1	-3.9	-7.8	-11.0	-10.7	-9.7
1991	-7.0	-6.9	-4.9	-2.4	-2.6	-15.7	-5.7	-2.8	-6.7	-9.3	-15.4	-15.2
AVG	-13.5	-11.2	-11.4	-12.1	-8.2	-5.1	-2.8	-1.7	-4.2	-8.8	-14.2	-16.3
MAX	0.0	0.0	0.1	-0.1	0.0	0.5	0.2	0.4	0.0	0.1	-0.2	0.0
MIN	-24.3	-26.0	-22.2	-33.3	-28.5	-19.7	-11.4	-8.3	-12.4	-21.9	-27.3	-25.4

This alternative results in the most significant overall average decrease in salinity in the central and south Delta. Additionally, model results show even more significant decreases in salinity on a month-to-month basis.

Fisheries Improvements (Objective 2)

Because the TDF is screened, this alternative would provide additional flow for fish already present in the central Delta, while preventing fish upstream of Hood from being diverted to the central Delta—where survival rates have been shown to be lower than in the Sacramento River system. Additional flows in the central Delta would also limit flows through the DCC, which would also benefit fish by reducing entrainment in the central Delta. However, peak flows in the TDF occur in the months of July and August, when central Delta fish have a relatively low expected occurrence (Table 8-2). Thus, benefits to these fish would be relatively limited. Species such as longfin smelt and splittail may benefit to a greater extent,

as larval and juvenile rearing in the central Delta may continue to occur during the months of July and August.

This alternative would decrease flows in the Sacramento River downstream of Hood; however, this decrease would result in increased residence time for fish in the Sacramento River and a greater length of exposure to predators within the river.

Results from PTM show that if more water is provided to the central Delta, a lower percentage of particles that started in the central Delta would eventually arrive at the export facilities. For example, the PTM results indicate a decrease from approximately 26 to 39 percent in entrainment of fish residing in the lower Mokelumne River downstream of Georgiana Slough, as shown in Table 8-11. This alternative is a benefit to all central Delta fish species that may continue to be present in those months of this alternative’s operations. PTM results show that particles originating at Dutch Slough have a lower chance of entrainment at the export facilities under the TDF alternative compared to the baseline (approximately 63 to 77 percent). While the overall estimated PTM capture percentages for both the baseline and the TDF alternatives are relatively low (approximately 8 percent to 23 percent), the TDF Alternative would provide significant improvements for fish residing in the Dutch Slough vicinity.

TABLE 8-11
Capture at Export Pumps for Alternative E1 (Through-Delta Facility)

Period	Capture	San Joaquin River near Antioch, downstream of Dutch Slough	Mokelumne River above San Joaquin River, downstream of Georgiana Slough	Sacramento River upstream of Hood	San Joaquin River at Fourteen Mile Slough
Mar-90	% Capture	1.8	36.6	N/A	84.9
	% Decrease from Baseline	76.6	38.9	N/A	-3.4
Feb-76	% Capture	5.8	61.2	N/A	95.7
	% Decrease from Baseline	75.4	26.4	N/A	-2.2
Apr-76	% Capture	3	26.3	N/A	63.9
	% Decrease from Baseline	62.5	35.7	N/A	4.2

However, the additional flow into the central Delta with this alternative would limit the ability for the upper San Joaquin River to “push” flows (and fish) through the Delta to the west. As a result, with this alternative, more San Joaquin River water may be directed toward the export facilities. At Fourteen Mile Slough, PTM results show a small (3 percent) detriment to fish that originate in the San Joaquin River (which could include fall-run San Joaquin River origin

Chinook salmon, splittail, and others). However, this percentage is small relative to the overall benefit to fisheries at the other locations within the central Delta.

Cost Estimate

The Through-Delta Facility Pre-feasibility Study (DWR, 2007b) estimated the capital cost of this alternative to be approximately \$360 million.

Alternative F1: DCC Modifications and Re-operation

The Delta Cross Channel Modifications and Re-operation Alternative involves increasing the flow from the Sacramento River to the Central Delta through the Delta Cross Channel. The DCC Alternative consists of three components:

- Enlarging the cross channel gates to allow increased flow by adding a third 60-foot-wide radial gate.
- Dredging the Mokelumne River downstream of the DCC to increase conveyance capacity and to allow increased flow to the central Delta through the DCC.
- Modifying the operation of the DCC gates to include day/night operations. The gates would be opened during the day during the seasons when they would normally be closed to protect fisheries, under the assumption that fish are more active during the night, and thus more likely to enter the central Delta at night.

Operations and Hydrodynamics

Table 8-12 summarizes the operation of the DCC gates in the baseline simulation. Months in which the gate remains completely closed are shaded gray. Standard gate operations include closing the gates for 45 days between November and January; closing the gates for the months of February through May; and opening the gates for the months of July, August, September, and October. The gate is also closed during periods of high flow on the Sacramento River as a flood and erosion control measure and for 4 days in June. In DSM2, the standard 45-day closure for the months of November through January is distributed throughout the 3 months as follows: 10 days in November, 15 days in December, and 20 days in January. The gate is opened at the beginning of the month, and then closed for the prescribed number of days at the end of the month. This is consistent with treatment of the DCC in CALSIM. (DSM2 uses CALSIM II output to specify most boundary conditions, including operation of the DCC.)

Model simulations were conducted to determine the relative importance of each of the three alternative components previously described. Table 8-13 summarizes the increase in monthly average flow through the DCC, relative to the baseline simulation, for three separate model runs: one with only day/night operations; a second with day/night operations and dredging on the Mokelumne River; and the third with day/night operations, dredging, and widening of the DCC. This final version of the DCC Alternative with all three actions is the alternative analyzed in this Study.

TABLE 8-12
Summary of Baseline Operation of Delta Cross Channel Gates (Days Closed)

WY	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975	0	10	15	20	28	31	30	31	30	0	0	0
1976	0	10	15	20	29	31	30	31	4	0	0	0
1977	0	10	15	20	28	31	30	31	4	0	0	0
1978	0	10	15	31	28	31	30	31	4	0	0	0
1979	0	10	15	20	28	31	30	31	4	0	0	0
1980	0	10	15	31	29	31	30	31	4	0	0	0
1981	0	10	15	20	28	31	30	31	4	0	0	0
1982	0	30	31	31	28	31	30	31	4	0	0	0
1983	0	30	31	31	28	31	30	31	30	0	0	30
1984	0	30	31	31	29	31	30	31	4	0	0	0
1985	0	30	15	20	28	31	30	31	4	0	0	0
1986	0	10	15	20	28	31	30	31	4	0	0	0
1987	0	10	15	20	28	31	30	31	4	0	0	0
1988	0	10	15	31	29	31	30	31	4	0	0	0
1989	0	10	15	20	28	31	30	31	4	0	0	0
1990	0	10	15	20	28	31	30	31	4	0	0	0
1991	0	10	15	20	28	31	30	31	4	0	0	0

Note: Gray cells indicate gates are closed all month.

TABLE 8-13
Comparison of Monthly Average Flow through DCC for Three DCC Alternatives

Month	Baseline (cfs)	Increase from Baseline (cfs)		
		Day/Night Ops	Day/Night Ops; Dredging	Day/Night Ops; Dredging; Third Gate
Oct	3,631	0	351	932
Nov	1,636	302	484	798
Dec	1,660	521	727	1,081
Jan	924	542	688	924
Feb	0	672	743	853
Mar	0	536	601	686
Apr	0	1,254	1,420	1,616
May	0	1,313	1,497	1,703
Jun	2,986	251	573	1,087
Jul	4,660	0	451	1,194
Aug	4,231	0	410	1,084
Sep	3,403	11	344	887

Results demonstrate that the relative increase associated with each individual alternative component varied with time. For example, the increased flow associated with the day/night operations is responsible for the majority of the increase in flow during February through May when the gate was completely closed during the baseline simulation. Day/night operations also accounted for a significant increase in flow during the months of December and January, when the gate was closed for extended periods. The addition of the third radial gate accounts for the majority of the flow increase during the months of June through October. These results are presented in Figure 8-5. Three additional model runs were conducted to show the incremental improvements of a third gate only, dredging only, and the combination of a third gate and dredging.

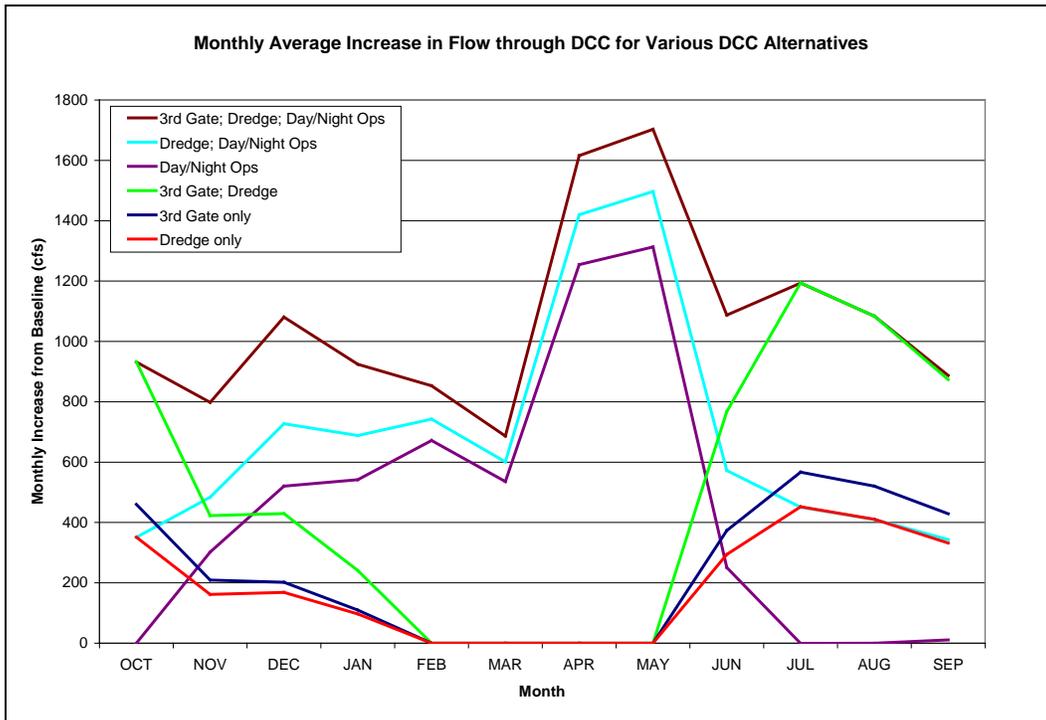


FIGURE 8-5
Monthly Average Increase in Flow through DCC for Various DCC Alternatives

Water Quality Improvements (Objective 1)

The influence of increased flows through the DCC on salinity at the export facilities is shown in Figure 8-6 for three variations of the DCC Alternative. Note that the inclusion of all three project components yields the largest decrease in salinity, although the magnitude of the influence varies considerably with time. The alternative has a larger influence on salinity in the south Delta during periods of elevated salinity (July through September); effects are muted during periods of low salinity (March through May).

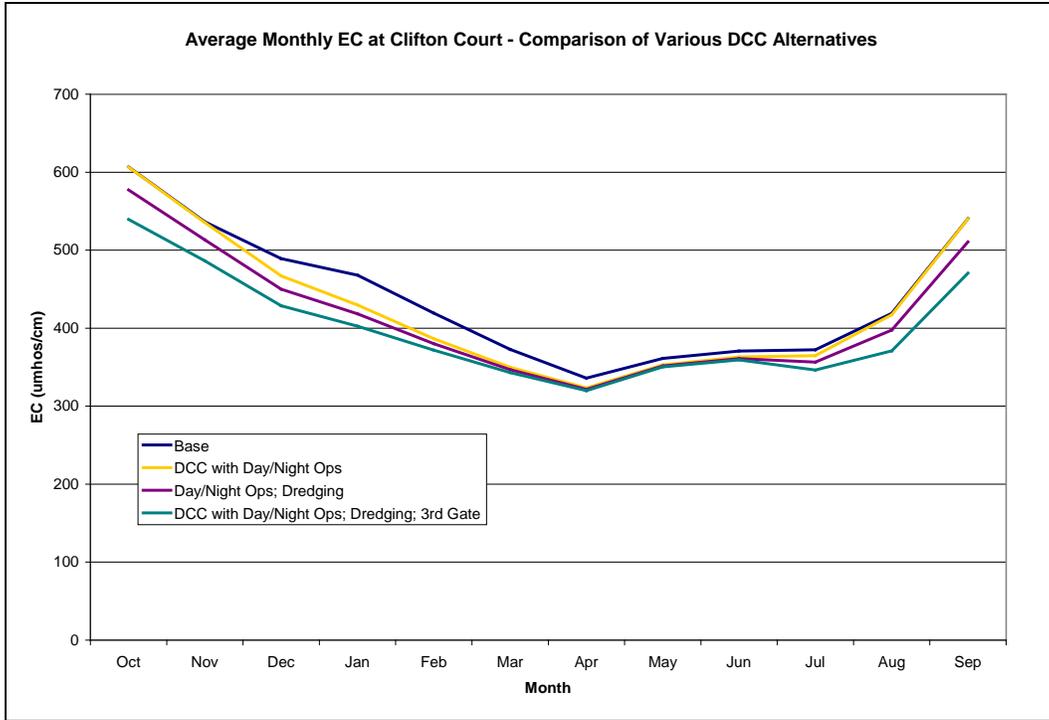


FIGURE 8-6
Comparison of Monthly Average EC at Clifton Court for Various DCC Alternatives

The largest increases in flow through the DCC Modifications and Re-Operation Alternative (third gate, day/night operations, and dredging), as compared to the baseline simulation, occur during the months of April and May. However, the largest improvements in water quality (decreases in salinity) are seen during the winter months. The biggest drop in EC of 16 percent is seen in Old River at Rock Slough, as shown in Figure 8-7. Jersey Point EC is also reduced by up to 15 percent. At the south Delta export facilities, average annual decreases in salinity are 9 percent at Clifton Court and 6.3 percent at the Jones Pumping Plant. In terms of water quality, this is a high-performing alternative.

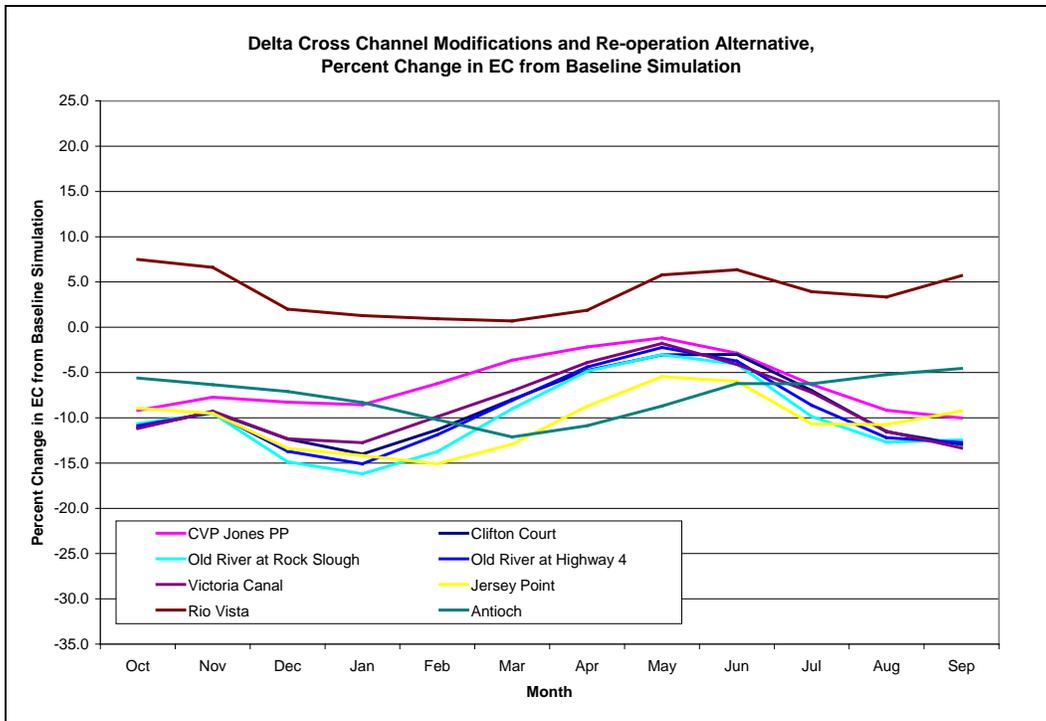


FIGURE 8-7
Delta Cross Channel Modifications and Re-operation Alternative,
Percent Change in EC from Baseline Simulation

Fisheries Improvements (Objective 2)

The largest increase in flows through the DCC Modifications and Re-operation Alternative compared to the baseline simulation occurs during the months of April and May. As shown in Table 8-2, these are primary months for which juvenile Chinook salmon and steelhead, as well as all other Delta species of concern, may be present in the project area. The PTM simulations used the Sacramento River at the Hood insertion point to determine how many particles move westward toward Steamboat and Sutter Sloughs, or stay in the Sacramento River versus those that move eastward toward the Mokelumne River system. If, for a given alternative, the PTM results indicate that more particles go to the east (toward the Mokelumne River system), it follows that the alternative may have negative effects on the fish species of concern.

As shown in Table 8-14, for the particles inserted at Hood, there are small (approximately 1 to 18 percent) decreases in entrainment of particles into the Delta export facilities compared to the baseline. Similarly, from the PTM analyses, for particles inserted within the Mokelumne River upstream of the San Joaquin River confluence, there are also small (approximately 6 to 16 percent) decreases in entrainment of particles into the Delta export facilities. The absolute percent of particle capture remains high for Mokelumne-inserted particles (approximately 38 to 79 percent) and moderately high for Hood-inserted particles (16 to 38 percent), as shown in Table 8-14.

TABLE 8-14
Capture at Export Pumps for Alternative F1 (DCC Modifications and Re-operation)

Period	Capture	San Joaquin River near Antioch, downstream of Dutch Slough	Mokelumne River above San Joaquin River, downstream of Georgiana Slough	Sacramento River upstream of Hood	San Joaquin River at Fourteen Mile Slough
Mar-90	% Capture	5.2	50.6	22.9	83
	% Decrease from Baseline	32.5	15.5	10.5	-1.1
Feb-76	% Capture	13.6	78.5	37.9	94.9
	% Decrease from Baseline	42.4	5.6	1.0	-1.4
Apr-76	% Capture	6.2	37.7	15.6	60.7
	% Decrease from Baseline	22.5	7.8	17.5	9.0

Furthermore, the PTM results may not completely portray the effects of the DCC alternatives on some fish species, especially juvenile salmonids in the central Delta. The DCC Modifications and Re-operation Alternative would increase flows through the DCC by modifying the DCC and adding an additional gate. With this alternative, the entrainment of fish into the central Delta may actually increase overall despite the PTM results, which indicate lower entrainment at the export facilities. Increases in juvenile salmonid entrainment into the central Delta would be detrimental to migrating salmonids due to increased losses from predation and to exposure to poorer water quality in the central Delta or to an overall delay in migrating out to the ocean.

As shown in Table 8-14, effects to fish, as predicted by the PTM for particles inserted on the San Joaquin River near Dutch Slough or at Fourteen Mile Slough, are small or inconsequential, ranging from a 1 percent increase in entrainment to a decrease of 14 percent at the Delta export facilities.

Cost Estimate

The TDF Value Engineering Study (DWR, 2007a) estimated the construction cost of this alternative at approximately \$141 million, which includes refurbishing the DCC gates, increasing capacity to 4,000 cfs, and adding fish screens and a bypass system on the new gate. This does not include the cost of design, permits, or construction management. This estimate does not include downstream channel improvements (levee modifications or channel dredging).

Alternative F2: DCC Re-operation

The re-operation of the DCC has been a significant subject of study since the start of the CALFED Bay-Delta Program. Under CALFED's Preferred Program Alternative, north Delta conveyance facilities improvements included evaluating

and implementing improved operational procedures for the Delta Cross Channel to address fishery and water quality concerns. Studies coordinated and implemented by cooperating agencies with authority in Delta operations are ongoing, and include options such as closing the DCC seasonally for fish migration, tidal operation, and day/night operation. Alternative F2 focuses on a day/night re-operation scenario. The gates would be opened during the day during the seasons when they would normally be closed to protect fisheries, under the assumption that fish are more active during the night and thus more likely to enter the central Delta at night.

Operations and Hydrodynamics

The operational differences between the baseline and DCC Modifications and Re-operation Alternative are identical to those of the DCC Re-operation Only Alternative, summarized in Table 8-12. The difference between these two alternatives (Alternatives F1 and F2, respectively) is that the former includes physical and structural changes to the system (dredging in the Mokelumne River and addition of a third DCC gate) in addition to the operational changes.

On an annual average basis, the flow through the DCC in Alternative F2 is less than half than that of Alternative F1.

Compared to the baseline simulation, both Alternatives F1 and F2 result in lower flow in Three Mile Slough and higher flow in the central Delta. However, the deviation from the baseline at both locations is greater for Alternative F1 compared to Alternative F2. This is because the cross-Delta flow is greater in Alternative F1 compared to Alternative F2. Flows in the south Delta (Old River) are unaffected by the two alternatives since south Delta flows are primarily driven by exports, which remain unchanged for both of these alternatives.

Water Quality Improvements

Alternative F2 results in approximately a 3 to 4 percent decrease in salinity in Old River (Bacon Island and Highway 4) compared to the baseline. In the San Joaquin River, this alternative results in about a 5 percent decrease in salinity at Jersey Point. In the south Delta export facilities, this alternative results in a 3 percent and 2 percent decrease at Clifton Court and Jones Pumping Plant, respectively. Overall, this alternative is only about 30 percent as effective as the Alternative F1 at lowering EC at the export facilities.

Fisheries Improvements

As shown in Table 8-12, the biggest difference (increase) in flows for Alternative F2 compared to the baseline simulation occurs during the months of April and May. These are primary months for which juvenile Chinook salmon and all other Delta species of concern may be present in the project area. Therefore, Alternative F2 may increase the entrainment of fish into the central Delta compared to the baseline condition. Because the increase in flows produced by Alternative F2 would be less than the increase in flows produced by Alternative F1, entrainment would likely be less under Alternative F2 than Alternative F1. However, any additional increase in juvenile salmonid entrainment into the central Delta would be detrimental to migrating salmonids

due to increased losses from predation, exposure to poorer water quality in the central Delta, and a delay in migrating out to the ocean.

Cost Estimate

This alternative involves only operational changes, but operations and maintenance costs associated with implementing this alternative are expected. Additional field staff may be required to monitor operations and maintain gates due to the daily operation of the gate. There is a possibility that the current DCC gates, which were designed for occasional operation, may need to be modified to adequately accommodate a more frequent operation schedule. The operational cost of this alternative has not been estimated.

Alternative G: Mokelumne River Water Exchange

This alternative would increase Sacramento River water diversions to EBMUD through an exchange for increased Mokelumne River flows delivered to the central and south Delta.

Operations and Hydrodynamics

The Mokelumne River Water Exchange Alternative is based on a proposed exchange in which CVP contractor EBMUD would divert water from the Sacramento River through the Freeport Diversion during the months of April through September instead of diverting water from Pardee and Camanche Reservoirs. The water retained in the Pardee and Camanche Reservoirs would be released during the months of August and September to improve water quality conditions in the central and south Delta. EBMUD would have no change in monthly diversions, but would pull water from the Sacramento River instead of the Mokelumne River.

Table 8-15 summarizes the changes in flows in the Sacramento River and Mokelumne River associated with the water exchange proposed under this alternative.

TABLE 8-15
Summary of Flow Changes with Mokelumne River Water Exchange Alternative

Month	Decrease in Flow on the Sacramento River (cfs)	Increase in Flow on the Mokelumne River (cfs)
Oct	0.0	0.0
Nov	0.0	0.0
Dec	0.0	0.0
Jan	0.0	0.0
Feb	0.0	0.0
Mar	0.0	0.0
Apr	183.2	0.0
May	144.7	0.0
Jun	0.0	0.0
Jul	152.9	0.0

TABLE 8-15
Summary of Flow Changes with Mokelumne River Water Exchange Alternative

Month	Decrease in Flow on the Sacramento River (cfs)	Increase in Flow on the Mokelumne River (cfs)
Aug	154.5	474.9
Sep	163.0	322.7

The influence of the increased diversion from the Sacramento River is minimal considering the diversion’s magnitude (~160 cfs on average for 5 months) in comparison to flows in the Sacramento River. The flow increases in the Mokelumne River, on the other hand, can be significant, as shown in Figure 8-8. The increase in flows in the Mokelumne River in August and September of 475 and 323 cfs, respectively, can be considerably higher than baseline flows, as presented in Figure 8-8. Note that the Mokelumne River flows are capped at 2,000 cfs in Figure 8-8 to clearly demonstrate increases in flows at the lower end of the range.

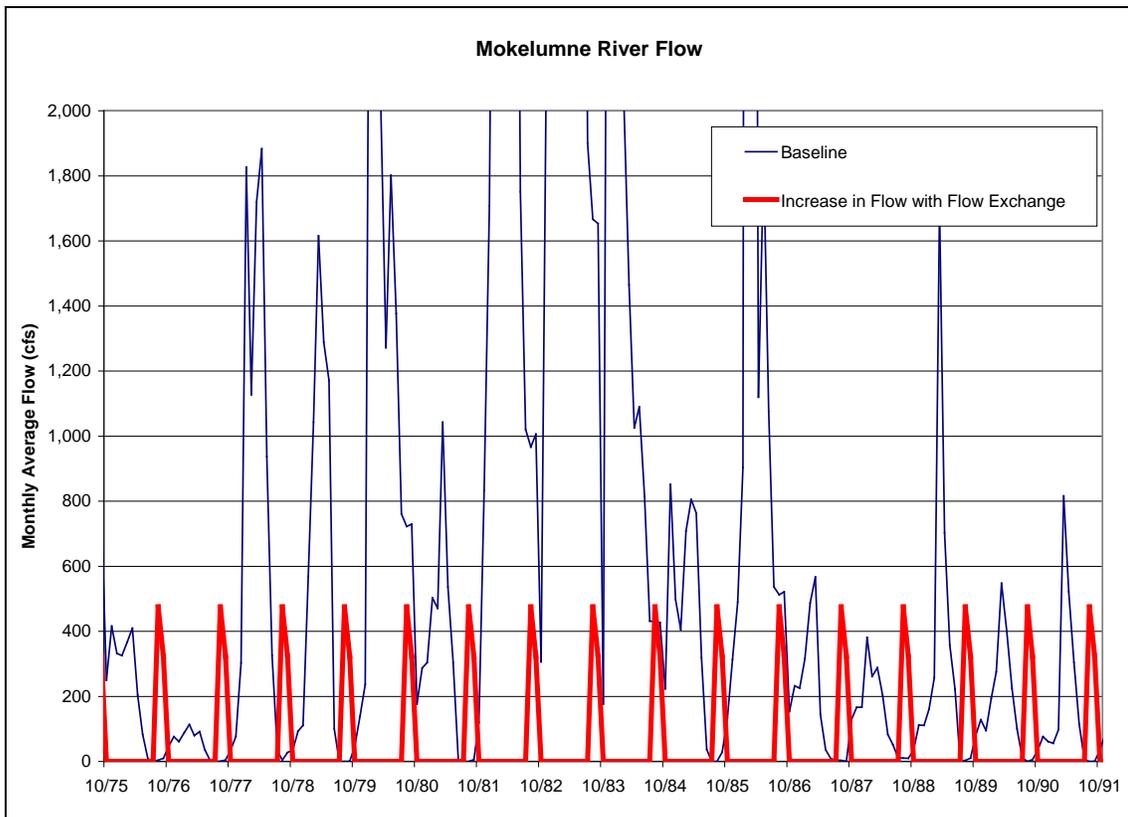


FIGURE 8-8
Comparison of Baseline Mokelumne River

Water Quality Improvements (Objective 1)

The August and September release of water stored in the Pardee and Camanche Reservoirs reduces salinity in the Delta by up to 10 percent. The benefits duration is relatively short and greatest in magnitude in Old River (Rock Slough and Highway 4). The decrease in flow in the Sacramento River causes a slight increase in the average EC at Antioch, Jersey Point, and Rio Vista (less than 5 percent) during the months of April through July, as shown in Figure 8-9.

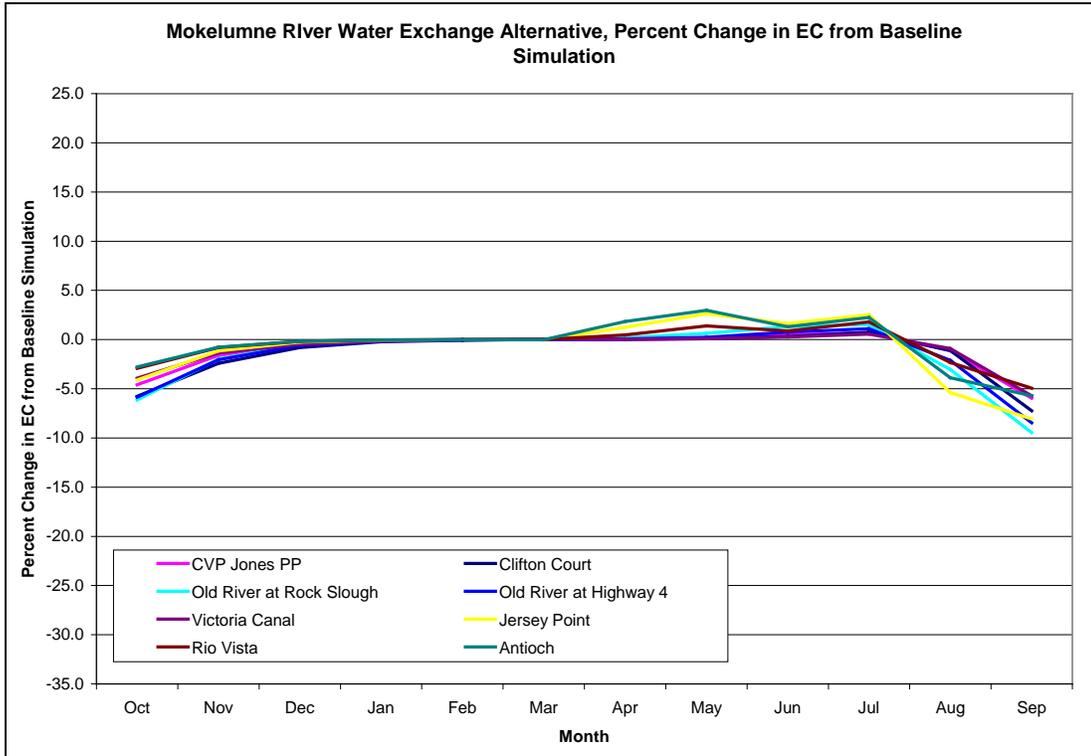


FIGURE 8-9
Comparison of Change in Monthly Average EC from Baseline Simulation for Mokelumne River Water Exchange Alternative

Fisheries Improvements (Objective 2)

This alternative alters the flow volumes and patterns in the Mokelumne and Sacramento Rivers between April and September, regardless of year type. The influence of the increased diversions from the Sacramento River are minimal during this period, considering the diversion's magnitude compared to flows in the Sacramento River during the April through May and July through September period. As shown in Table 8-2, while there are species of concern present during the April and May period, there is likely a low presence of juvenile fish of concern during the latter time period (July through September). Overall, given the magnitude of diversion flows from the Sacramento River and the timing in late summer, discernable benefit to Delta smelt, longfin smelt, or splittail are unlikely.

In contrast, the flow increases in the Mokelumne River can be significant. The increase in flows in the Mokelumne River in August and September of 475 and 323 cfs, respectively, would be considerably higher than baseline flows. The resulting increased attraction flows on the Mokelumne River could enhance immigration if adult Chinook salmon are present from late August and September. Although the onset of adult Chinook salmon upstream migration in the lower Mokelumne River has been documented as early as mid-August, the peak upstream migration during 1990 through 1999 was during late-October to mid-November; therefore, the increase in attraction flows may have minimal benefit, if any, to Mokelumne River fall-run Chinook salmon. Furthermore, adult steelhead migration would be expected to occur from October through February (Marine and Vogel, 2000) and this alternative would not likely benefit San Joaquin River steelhead.

Flow changes in the Sacramento River as a percentage of river flow would be too small to discern effects on the salmon runs present during that time period. Although on the Sacramento River there would be less attraction flow, the change is so small that it would not likely have a discernable effect on fish. Therefore, for this alternative, it is unlikely that significant benefits would be seen by any of the fish species of concern.

Cost Estimate

Because this alternative involves only operational and management changes, there is no facility cost associated with implementing this alternative. However, there would likely be annual or per-acre-foot cost associated with the exchange due to additional pumping costs at the Freeport Diversion and potentially higher water treatment costs that EBMUD may incur from using water from the Sacramento River versus Mokelumne River water. The operational cost of this management alternative has not been estimated.

Alternative H: Outflow Management/Sacramento River Flow Augmentation

The Outflow Management/Sacramento River Flow Augmentation Alternative seeks to increase flow on the Sacramento River through purchase of water in the northern Sacramento Valley. The increase in water is intended to improve water quality in the central and south Delta during late summer through early winter in critical years.

Operations and Hydrodynamics

The duration of the flow increase is year-type specific, with augmentation of 500 cfs in August through December in critical years, augmentation of 500 cfs in August and September in dry years, and augmentation of 500 cfs only in September for remaining year types. The increased flow occurrences are summarized in Table 8-16.

TABLE 8-16
Increase in Outflow Management/Sacramento River Flow Augmentation Alternative as Compared to the Baseline

Year	Year Type	Aug	Sept	Oct	Nov	Dec
1976	critical	500	500	500	500	500
1977	critical	500	500	500	500	500
1978	above normal	0	500	0	0	0
1979	below normal	0	500	0	0	0
1980	above normal	0	500	0	0	0
1981	dry	500	500	0	0	0
1982	wet	0	500	0	0	0
1983	wet	0	500	0	0	0
1984	wet	0	500	0	0	0
1985	dry	500	500	0	0	0
1986	wet	0	500	0	0	0
1987	dry	500	500	0	0	0
1988	critical	500	500	500	500	500
1989	dry	500	500	0	0	0
1990	critical	500	500	500	500	500
1991	critical	500	500	500	500	500

Water Quality Improvements (Objective 1)

Increased flows occur every September; thus, the largest water quality improvements are expected during September and October, allowing for travel time through the south Delta. Average changes in salinity vary between 0 and 15 percent, with peak influences in September and October, as shown in Figure 8-10. Improvements in salinity at the export locations average 9.3 percent at the Banks Pumping Plant and 8 percent at the Jones Pumping Plant in October.

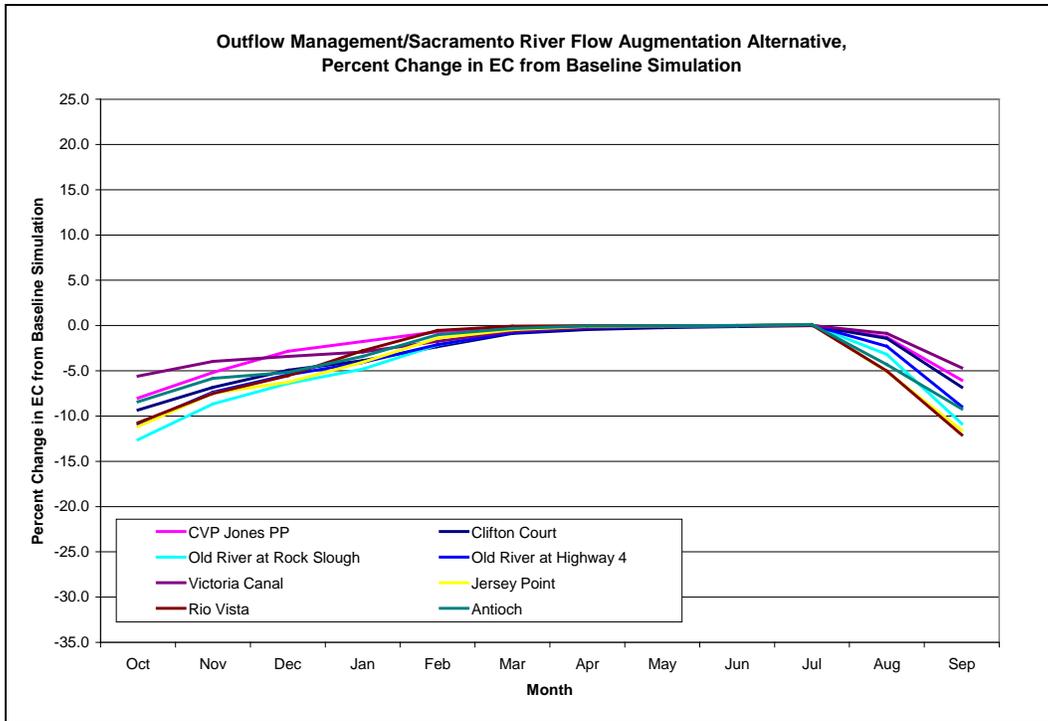


FIGURE 8-10
Outflow Management/Sacramento River Flow Augmentation
Percent Change in EC from Baseline Simulation

Fisheries Improvements (Objective 2)

The flow augmentation period is between August and December, depending on hydrology. All months experience flow augmentation in 5 out of 16 years, only August and September in 4 out of 16 years, and only September in 7 out of 16 years. Therefore, the benefit period for fish would primarily be in September and October.

The early life stages of Chinook salmon, steelhead, Delta and longfin smelt, and splittail do not have a significant presence during the main flow augmentation period between September and October, as shown in Table 8-2. Additionally, the additional flow is such a small percentage of the total flow that positive or negative effects on fish would unlikely be measurable, given the current understanding of Delta fish species. Therefore, this alternative was screened from the analysis.

Cost Estimate

The primary mechanism for implementation of this alternative would involve the transfer of water from Sacramento Valley irrigation districts for the purpose of leaving it in the Sacramento River, thereby increasing Delta outflow. A cost estimate is based on an average of 500 cfs over 2 months at \$200 to \$300 per acre-foot. The cost of the transfer would be approximately \$12 million to \$18 million per year on average.

Summary Comparison of Alternatives

Seven NoCDIS alternatives were compared to determine relative influences on hydrodynamics, water quality, and fisheries compared to a baseline simulation. The numerical analysis was conducted with the widely accepted DSM2 model developed by DWR. The PTM model was also used to gauge influences on larval and juvenile life stage fisheries.

Hydrodynamics

A review of annual average flows for the baseline and each alternative indicates that changes in Delta hydrodynamics from the baseline simulation vary greatly from alternative to alternative, and that differences in flows can be either confined to the region near the operational or structural change, as is the case for the Three Mile Slough Alternative and the West False River Alternative, or distributed over a larger area, such as with the TDF Alternative and the two DCC alternatives.

The cross-Delta flow—defined as the flow through the DCC and any flow diverted into the TDF—results for the baseline and seven NoCDIS alternatives are compared in Figure 8-11. The largest cross-Delta flows are associated with the TDF Alternative. The DCC Modifications and Re-operation Alternative (F1) also yields a substantial increase in cross-Delta flow. All remaining alternatives lack significant influence on cross-Delta flow. The increase in flow into the north-central Delta for the TDF Alternative and the DCC Modifications and Re-operation Alternative drains into the San Joaquin River, thus increasing the net downstream flows in the Mokelumne River, Potato Slough, Little Potato Slough, and Disappointment Slough. Increases in cross-Delta flow result in decreased flows in the Sacramento River downstream of the DCC.

Variations in flow in the south Delta are relatively minor between alternatives because of the constant treatment of export flows and Delta Island consumptive use in the south Delta for all alternatives. There may be minor differences in the distribution of water flowing through south Delta channels (Old River, Middle River, Turner Cut, etc.), but the total flow is constant for each alternative.

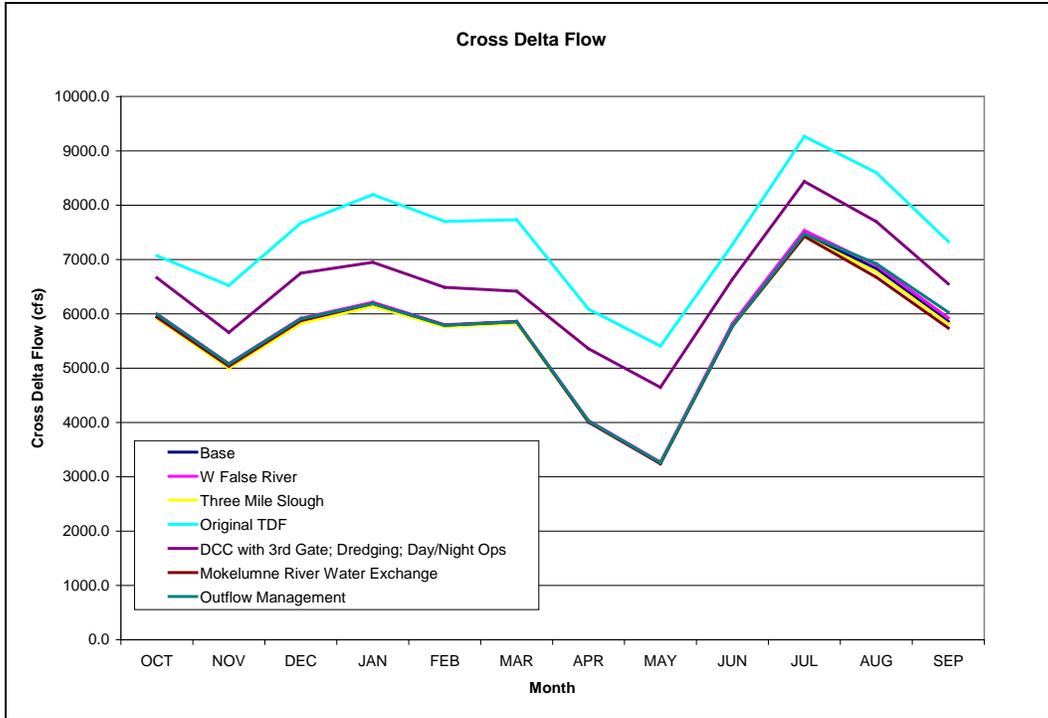


FIGURE 8-11
Comparison of Cross-Delta Flow for NoCDIS Alternatives

Water Quality Objective

The proposed geometric and operations changes associated with the NoCDIS alternatives impart changes to the net flows and transport pathways in the Delta which, in turn, influence water quality. Model results indicate that, on average, a TDF (Alternative E1) provides the largest decrease in salinity in the south Delta, followed by DCC Modifications and Re-operation (Alternative F1). Among the two Franks Tract alternatives, Operable Gates on Three Mile Slough (Alternative D) provides a greater decrease in salinity than the Operable Gates on False River (Alternative A). The Mokelumne River Water Exchange (Alternative G) and Sacramento River Flow Augmentation (Alternative H) perform well, but only during the months of September and October.

An overview of variations in salinity at key locations in the Delta for different model runs is provided in Table 8-17. Period averaged results at the location listed above are summarized in Table 8-17. The values presented in Table 8-17 have been averaged over the 16-year simulation period. For each of the 12 locations, the alternative with the largest percent decrease in EC from the baseline is shaded yellow and the second largest is shaded green. Table 8-18 presents the same comparison, except monthly instead of annually for the two export locations (SWP and CVP). Water quality modeling results for two locations in the south Delta are shown in Figures 8-12 and 8-13.

TABLE 8-17
Comparison of Average (16-year) Change in EC for all NoCDIS Alternatives (in percent change from baseline)

Delta Location	Baseline (Average Annual EC, µmhos/cm)	Alt A West False River	Alt D Three Mile Slough	Alt E1 Through- Delta Facility	Alt F2 DCC Re-operation Only	Alt F1 DCC Modifications and Re-operation	Alt G Mokelumne River Water Exchange	Alt H Outflow Management
Collinsville	3,863	-3.8	0.3	1.6	0.4	1.1	0.0	-2.1
Antioch	2,056	-4.6	-15.9	-16.8	-3.7	-7.6	-0.4	-3.1
Emmaton	1,093	-3.2	0.7	11.0	1.4	4.2	-0.2	-4.1
Rio Vista	284	-0.4	-3.2	11.5	0.7	3.8	-0.6	-3.7
Jersey Point	1,069	-5.8	-20.5	-19.7	-4.7	-10.4	-0.9	-4.0
OLDR_BAC	478	-9.0	-10.7	-18.5	-4.1	-10.1	-1.5	-4.1
ROCK_SL_PP1	536	-7.8	-9.2	-15.8	-3.2	-8.7	-1.4	-3.7
OLDR_HWY4	464	-6.4	-8.9	-16.6	-3.4	-9.4	-1.4	-3.5
Middle River Intake	393	-1.7	-4.3	-13.4	-2.7	-8.8	-1.0	-2.0
Victoria Canal Intake	397	-1.6	-4.2	-13.2	-2.6	-8.7	-1.0	-2.0
Clifton Court	441	-4.8	-7.7	-15.2	-3.1	-9.0	-1.4	-3.1
CVP Tracy	475	-3.6	-5.3	-10.5	-1.9	-6.3	-1.0	-2.2

Note: Yellow-shaded results signify the best performing alternative; green-shaded results signify the second best performing alternative.

Chapter 8: Comparison of Alternatives

TABLE 8-18
Comparison of Average Monthly Change in EC at all Exports for all NoCDIS Alternatives (in percent change from baseline, by month)

Location	Month	Baseline (Average Monthly EC, µmhos/cm)	Alt A West False River	Alt D Three Mile Slough	Alt E1 Through- Delta Facility	Alt F2 DCC Re-operation Only	Alt F1 DCC Modifications and Re-operation	Alt G Mokelumne River Water Exchange	Alt H Outflow Management
Clifton Court (SWP Banks Pumping Plant)	Oct	607	-7.8	-9.3	-17.7	0.0	-11.1	-5.8	-9.3
	Nov	536	-7.7	-6.4	-13.4	-0.2	-9.4	-2.4	-6.8
	Dec	489	-7.6	-7.4	-18.4	-4.5	-12.3	-0.8	-4.9
	Jan	468	-5.4	-13.2	-23.1	-8.2	-14.0	-0.2	-3.9
	Feb	419	-3.8	-12.6	-20.4	-7.9	-11.3	-0.1	-2.3
	Mar	373	-2.0	-7.8	-15.3	-6.1	-8.0	0.0	-0.9
	Apr	336	-1.0	-4.3	-9.4	-3.7	-4.8	0.0	-0.4
	May	361	-0.6	-2.2	-6.3	-2.3	-3.1	0.1	-0.2
	Jun	371	-1.2	-0.7	-6.3	-2.0	-3.0	0.3	-0.1
	Jul	372	-4.4	-4.0	-11.7	-2.0	-7.0	0.7	0.0
Aug	419	-7.2	-11.9	-19.0	-0.5	-11.5	-1.1	-1.4	
Sep	540	-8.3	-12.9	-21.9	-0.1	-12.9	-7.2	-6.8	

Note: Yellow-shaded results signify the best performing alternative; green-shaded results signify the second best performing alternative.

TABLE 8-18

Comparison of Average Monthly Change in EC at all Exports for all NoCDIS Alternatives (in percent change from baseline, by month)

Location	Month	Baseline (Average Monthly EC, µmhos/cm)	Alt A West False River	Alt D Three Mile Slough	Alt E1 Through- Delta Facility	Alt F2 DCC Re-operation Only	Alt F1 DCC Modifications and Re-operation	Alt G Mokelumne River Water Exchange	Alt H Outflow Management
CVP Jones Pumping Plant	Oct	607	-6.6	-7.3	-15.0	0.0	-9.2	-4.6	-8.0
	Nov	542	-6.3	-5.1	-12.0	-0.2	-7.7	-1.6	-5.2
	Dec	512	-4.7	-5.1	-12.8	-3.3	-8.3	-0.4	-2.8
	Jan	483	-2.8	-8.8	-14.5	-5.2	-8.6	-0.1	-1.8
	Feb	454	-1.6	-7.6	-11.0	-4.5	-6.2	0.0	-0.7
	Mar	459	-0.8	-3.6	-6.5	-2.9	-3.6	0.0	-0.3
	Apr	390	-0.5	-1.9	-3.9	-1.7	-2.2	0.0	-0.1
	May	394	-0.2	-0.7	-2.2	-0.9	-1.2	0.1	-0.1
	Jun	385	-1.8	-0.2	-5.2	-1.8	-2.9	0.5	0.0
	Jul	403	-4.7	-3.5	-10.0	-1.5	-6.3	0.7	0.0
	Aug	466	-5.9	-9.4	-15.4	-0.3	-9.2	-1.1	-1.3
	Sep	605	-6.6	-9.9	-17.4	0.0	-10.0	-6.0	-6.0

Note: Yellow-shaded results signify the best performing alternative; green-shaded results signify the second best performing alternative.

This page intentionally left blank.

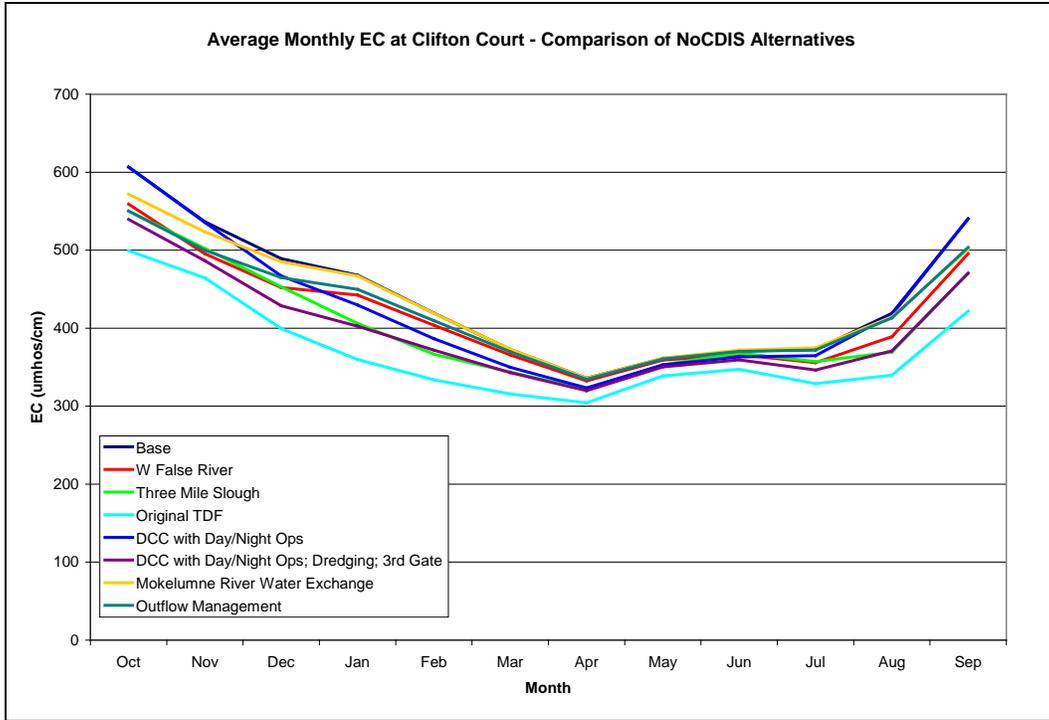


FIGURE 8-12
Average Monthly EC at Clifton Court Forebay: Comparison of NoCDIS Alternatives

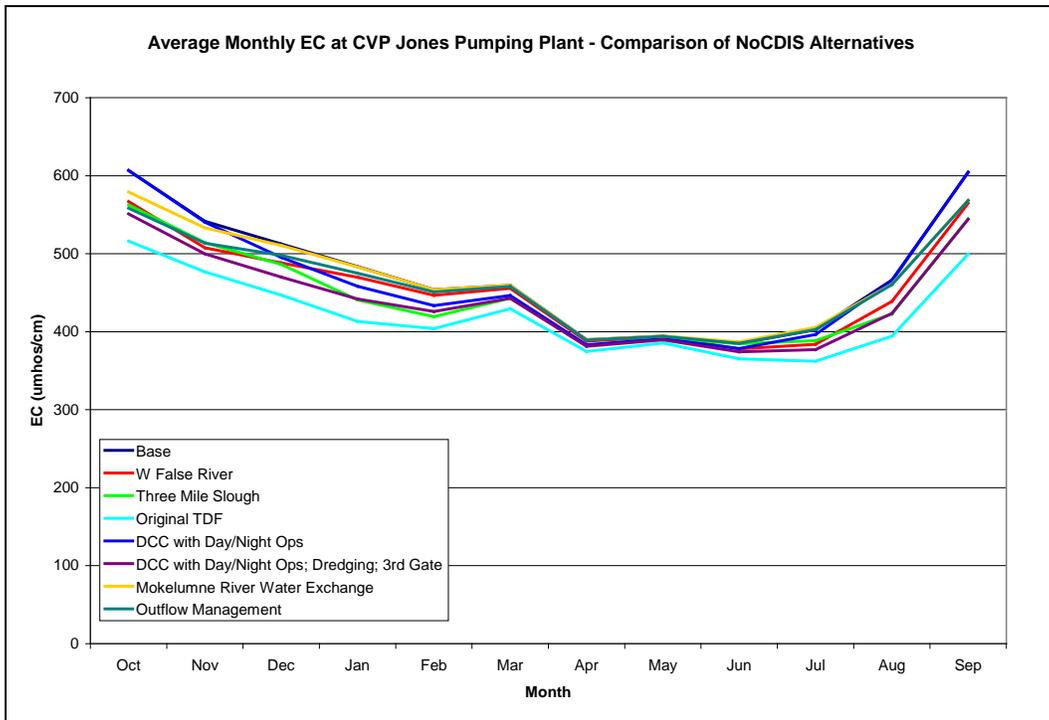


FIGURE 8-13
Average Monthly EC at CVP Jones Pumping Plant: Comparison of NoCDIS Alternatives

In general, the TDF (Alternative E1) yields the largest improvements in water quality (most significant decreases in salinity) in the south Delta, shown in Figures 8-13 and 8-14. DCC Modifications and Re-operation (Alternative F1) performs second best in reducing salinity at the export facilities. Operable Gates on Three Mile Slough (Alternative D) outperforms Operable Gates on West False River (Alternative A) which, in turn, outperforms the Outflow Management/Sacramento River Flow Augmentation (Alternative G), DCC Re-operation Only (Alternative F2), and the Mokelumne River Water Exchange (Alternative H), listed in decreasing order of performance.

Fish Objective

Results of the PTM simulations indicate a high degree of variability in effects on fisheries in the central Delta, depending largely on the particle insertion point (or fish location) and the alternative operations and hydrodynamics. Table 8-19 summarizes the percent capture (take) at the south Delta export facilities for three sets of PTM simulations. These runs represent 90th percentile exceedance flows on the Sacramento River, and thus may be representative of somewhat “worst-case” conditions for fish (low flow scenarios).

These PTM results indicate that during low river flow conditions, the relative benefit of each alternative can vary considerably and is particularly dependent on the particle release location.

San Joaquin River Downstream of Dutch Slough

For releases in the San Joaquin River downstream of Dutch Slough, a TDF (Alternative E1) reduces the capture at the pumps by between 63 percent and 77 percent, as shown in Table 8-19. However, except as shown for the February 1976 PTM simulation, the predicted take of fish at the Delta export facilities would remain relatively low and relatively unchanged from that of the baseline condition (2 to 6 percent entrainment versus 8 percent for the baseline). Therefore, the benefit to Delta and longfin smelts would be relatively small for that alternative.

Operable Gates on Three Mile Slough (Alternative D) also appears to be very effective at reducing capture, with results indicating a decrease of between 21 percent and 62 percent for three different PTM time period simulations. Once again, except for the February 1976 PTM simulation, the predicted take of fish at the export facilities with Operable Gates on Three Mile Slough would remain relatively low and unchanged (approximately 4 to 6 percent entrainment versus 8 percent for the baseline); therefore, the benefits to fish are rather small, as shown in Table 8-19. These results are based on operating gates primarily for water quality purposes.

TABLE 8-19
Summary of Capture at Export Facilities at end of 120-day PTM Simulation by Insertion Point

Alternative	Period	San Joaquin River downstream of Dutch Slough		Mokelumne River downstream of Georgiana Slough		Sacramento River upstream of Hood		San Joaquin River at Fourteen Mile Slough	
		Take (%)	Decrease in Take vs. Baseline (%)	Take (%)	Decrease in Take vs. Baseline (%)	Take (%)	Decrease in Take vs. Baseline (%)	Take (%)	Decrease in Take vs. Baseline (%)
Baseline	Mar-90	7.7		59.9		25.6		82.1	
Alternative B West False River	Mar-90	5.5	28.6	57.1	4.7	22.4	12.5	82.5	-0.5
Alternative D Three Mile Slough	Mar-90	4.1	46.8	58.6	2.2	25	2.3	81.6	0.6
Alternative E1 TDF	Mar-90	1.8	76.6	36.6	38.9	N/A	N/A	84.9	-3.4
Alternative F1 DCC Mod/Re-op	Mar-90	5.2	32.5	50.6	15.5	22.9	10.5	83	-1.1
Alternative F2 DCC Re-op Only	Mar-90	5.4	29.9	52.9	11.7	23.3	9.0	83.8	-2.1
Baseline	Feb-76	23.6		83.2		38.3		93.6	
Alternative B West False River	Feb-76	20.2	14.4	84.7	-1.8	37.5	2.1	94.1	-0.5
Three Mile Slough	Feb-76	9	61.9	79	5.0	41.1	-7.3	94.5	-1.0
Alternative E1 TDF	Feb-76	5.8	75.4	61.2	26.4	N/A	N/A	95.7	-2.2
Alternative F1 DCC Mod/Re-op	Feb-76	13.6	42.4	78.5	5.6	37.9	1.0	94.9	-1.4
Alternative F2 DCC Re-op Only	Feb-76	13.3	43.6	78.8	5.3	35.9	6.3	94.4	-0.9
Baseline	Apr-76	8		40.9		18.9		66.7	
Alternative B West	Apr-76	6.1	23.8	41.7	-2.0	17	10.1	62.8	5.8

Chapter 8: Comparison of Alternatives

TABLE 8-19
Summary of Capture at Export Facilities at end of 120-day PTM Simulation by Insertion Point

Alternative	Period	San Joaquin River downstream of Dutch Slough		Mokelumne River downstream of Georgiana Slough		Sacramento River upstream of Hood		San Joaquin River at Fourteen Mile Slough	
		Take (%)	Decrease in Take vs. Baseline (%)	Take (%)	Decrease in Take vs. Baseline (%)	Take (%)	Decrease in Take vs. Baseline (%)	Take (%)	Decrease in Take vs. Baseline (%)
False River									
Three Mile Slough	Apr-76	6.3	21.3	42.6	-4.2	17.1	9.5	60.7	9.0
Alternative E1 TDF	Apr-76	3	62.5	26.3	35.7	N/A	N/A	63.9	4.2
Alternative F1 DCC Mod/Re-op	Apr-76	6.2	22.5	37.7	7.8	15.6	17.5	60.7	9.0
Alternative F2 DCC Re-op Only	Apr-76	5.4	32.5	39.2	4.2	17.1	9.5	62.7	6.0

Note: For each combination of insertion point and period, yellow-shaded results signify the best performing alternative; green-shaded results signify the second best performing alternative.

Delta Cross Channel Modifications and Re-operations (Alternative F1) PTM results demonstrate reductions in take of between 23 percent and 42 percent, while Operable Gates on West False River (Alternative A) only reduces capture by between 14 percent and 28 percent for the periods used in the Study. Both Alternatives A and D provide very small overall reductions of entrainment of fish at the export facilities. The predicted take for all three PTM simulation periods ranges from 6 to 20 percent for Operable Gates on West False River (versus 8 to 23 percent take for baseline) and from 5 to 14 percent take (verses 8 to 24 percent take for baseline) for the DCC Modifications and Re-operation (Alternative F1). Both are rather small benefits to fisheries in the central Delta, but as noted previously, operations were focused on water quality benefits rather than fish benefits.

Mokelumne River Upstream of the San Joaquin River, Downstream of Georgiana Slough

For releases on the Mokelumne River, the TDF demonstrated a significant reduction in capture at the export facilities compared to the baseline condition when the estimated percentage of take was examined. The predicted take at the export facilities for this alternative ranged from approximately 26 to 37 percent compared to 41 percent up to 83 percent for the baseline condition. This large reduction in take indicates significant benefits to central Delta fish, primarily associated with the increase in screened diversion flows from the north Delta into the San Joaquin River with the TDF (Alternative E1). Thus, Alternative E1 would provide significant benefit for fishes within the central Delta.

The DCC Modifications and Re-operation (Alternative F1) also demonstrated reduced capture rates of 6 percent to 16 percent for releases on the Mokelumne River, but, as discussed previously, these reductions in predicted take may underestimate the potential for adverse effects to juvenile salmonids entrained into the central Delta as a result of increased flows through the DCC. Therefore, this alternative is likely not as beneficial to fisheries as would be indicated by the PTM results alone. Finally, as predicted by the PTM results, the Franks Tract Alternatives (Operable Gates on Three Mile Slough and Operable Gates on West False River [Alternatives D and A]) showed little variation from the baseline, and therefore few effects to fisheries in the central Delta.

Sacramento River Upstream of Hood and San Joaquin River at Fourteen Mile Slough

For particle releases in the Sacramento River near Hood and in the San Joaquin River at Fourteen Mile Slough, all alternatives demonstrated minor differences from the baseline condition. Results, as measured by PTM simulations, did not consistently reduce entrainment at the export facilities and, for some alternative simulations, the capture increased by up to 7 percent. At these points, there are minimal benefits, if any, to fisheries for any of the alternatives.

Fish Objective Conclusion

The conclusions presented in the fisheries analysis are highly dependent on many assumptions, and reflect the uncertainties inherent in the current state of

knowledge. Therefore, the conclusions about the overall performance of any particular alternative relative to fisheries should be interpreted cautiously. It must also be noted that the alternatives evaluated were primarily operated to achieve the water quality objective, but were not optimized to achieve the most favorable conditions for fish; however, this optimization could be performed in future planning studies.

Based on the analyses of the PTM results, as predictive of the biological effects to fisheries, the TDF provides the most significant benefit to fish. This result is consistent with previous studies. The two Franks Tract Alternatives—Operable Gates on Three-Mile Slough and Operable Gates on West False River (Alternatives D and A)—may provide small but possibly unquantifiable benefits to fisheries in the central Delta when the gates are operated primarily for water quality purposes. The DCC Modifications and Re-operation (Alternative F1) provide relatively little benefit to fisheries. This conclusion is particularly applicable to Chinook salmon and steelhead, which are more likely to move into the central Delta, thereby increasing their residence time and exposure to poor water quality and predation. However, the additional water in the central Delta with the DCC alternative may be beneficial for Delta and longfin smelts and other central Delta fish by reducing entrainment at the export facilities.

The two management alternatives—Outflow Management/Sacramento River Flow Augmentation and Mokelumne River Flow Exchange—principally alter flows from April to June and August to September. Because the species of concern are generally not present during these months, these two alternatives do not result in an overall benefit to fisheries.

The benefits (or lack thereof) to fisheries from the alternatives analyzed previously must be carefully reviewed in the context of many unknown factors. As discussed previously, many benefits to water quality through seasonal operations occur during months when the fish species being considered are either not present in the central Delta or are present in low numbers. Even during months when these fish are potentially present, the use of the PTM analyses only provides an indication of possible benefit to fish compared to the baseline condition. Factors including fish population abundances, local environmental conditions, year-to-year variability in spatial and temporal distributions, predator and food abundance, and variability in hydrodynamics would all likely affect fisheries as part of any of the alternatives. Unfortunately, much of this information is currently unknown. Furthermore, conditions are continuously changing in the Delta with fish population abundances, varying short-term environmental conditions, and changing longer-term climate conditions. All of these unknown factors make projecting benefits to fisheries difficult.

Furthermore, although not specifically evaluated by this Study, operational schemes such as gate closure periods, originally established to improve water quality, could be altered to improve fish benefits during times when water quality is not limiting. For example, if it were decided that Operable Gates on Three Mile Slough (Alternative D) was to be implemented, operations of those gates outside the period for water quality improvement could be developed for fisheries

enhancement through an adaptive management process. In that manner, the overall net benefit for fisheries enhancement could be improved over that of the alternative as it was initially envisioned.

Cost Estimate Summary

To compare the range of alternative cost estimates across studies, capital costs were evaluated in 2010 dollars using a standardized approach, as shown in Table 8-20. The first step used to standardize cost estimates was to identify the capital costs solely for the water facility. All habitat restoration, contingency, and other markups were removed from the estimate. Unless noted otherwise, each capital cost estimate was assumed to contain mobilization and demobilization, bond, permit, and insurance, and overhead and profit markups. The only exception is the Moffatt & Nichol Flooded Islands Pre-feasibility Study presentation, “Salinity Control Gate Concept Cost Analysis,” which did not include contractor markups (profit and overhead). An assumed 20 percent was added for contractor markup for better comparison to other cost estimates. No operation, maintenance, removal, or relocation costs were included in any of the cost estimates.

Once a standardized capital cost was determined, a 25 percent contingency; 30 percent administration, legal, and engineering; and 15 percent miscellaneous and market allowance markup were added. The cost estimates were then escalated to 2010 dollars based on a 5 percent annual escalation rate. If the year of the cost estimate was not explicitly stated in the respective report, the year the report was issued was used. This approach to standardize the costs estimates allows for a better comparison of cost estimates across studies.

Summary

A summary of the alternatives comparison is presented in Table 8-21. The summary includes the comparison of alternatives based on the technical analysis described previously as part of the federal principles and guidelines criteria. The four criteria are effectiveness, completeness, efficiency, and acceptability. This combined investigation of all alternatives and relative performance with respect to planning objectives and the general planning criteria may provide the basis for screening or focusing the planning process in the plan formulation phase of the Feasibility Study. Descriptions of the four criteria as related to the NoCDIS are presented in the following discussion. The results presented here should be considered for coarse screening-level purposes only.

Effectiveness Criterion

The effectiveness criterion addresses how well an alternative would alleviate problems and achieve opportunities. This criterion considers how well the alternative would achieve the coequal planning objectives of water quality and fisheries improvement. For NoCDIS, if an alternative did not achieve improvements in terms of water quality or fish, it was considered incomplete.

Completeness Criterion

The completeness criterion addresses whether the alternative would account for all investments or other actions necessary to realize the planned effects. For the NoCDIS, completeness is considered with respect to the coequal objectives of improving water quality in the south Delta and improving fisheries conditions throughout the Delta.

Efficiency Criterion

The efficiency criterion addresses the extent to which an alternative plan is the most cost-effective means of alleviating the specified problems and realizing the specified opportunities consistent with protecting the nation's environment. At this IAIR stage of the NoCDIS, a cost comparison is presented based on the range of cost estimates developed by previous studies. Economic analysis of the alternatives will be a key component of the plan formulation phase of the NoCDIS.

Acceptability Criterion

The acceptability criterion addresses the viability of an alternative with respect to acceptance by state and local entities, and compatibility with existing laws. For the IAIR stage, a qualitative assessment of acceptability is performed with respect to consistency with ongoing Delta planning activities, as well as with other Reclamation projects and policies.

TABLE 8-20
Comparative Alternative Capital Costs (\$ 1,000,000)

Alternative	Capital Cost (Year)	25% Contingency	30% Administration, Legal, and Engineering	15% Miscellaneous and Market Allowance	Total Capital Cost (2010)	Source/Notes
Alternative A—Operable Gates on West False River	\$14.4 (2006)	\$18.0	\$23.4	\$26.9	\$32.0	Moffatt & Nichol Flooded Islands Feasibility Study (for DWR), presentation, "Salinity Control Gate Concept Cost Analysis." Costs based on temporary facility.
	\$49.9 (2007)	\$62.4	\$81.1	\$93.2	\$106.6	DWR Franks Tract Value Engineering Study. Costs based on permanent facility.
Alternative D—Operable Gates on Three Mile Slough	\$34.2 (2007)	\$42.8	\$55.6	\$63.9	\$73.1	DWR Franks Tract Value Engineering Study. Costs based on permanent facility.
Alternative E1—Through-Delta Facility	\$250.4 (2007)	\$313.0	\$406.9	\$467.9	\$534.9	DWR Technical Memorandum: Modeling of Value Engineering Study Alternatives for the Through-Delta Facility.
Alternative F1—Delta Cross Channel Modifications and Re-operation	\$108.0 (2007)	\$135.2	\$175.7	\$202.1	\$231.0	DWR Technical Memorandum: Modeling of Value Engineering Study Alternatives for the Through-Delta Facility. Costs do not include significant dredging and levee modification costs (\$100M).
Alternative F2—Delta Cross Channel Re-operation						Note: annual O&M costs and potential facility improvements not determined due to low effectiveness.
Alternative G—Mokelumne River Water Exchange						Note: annual costs (management, treatment, other costs) not determined due to low effectiveness.
Alternative H—Outflow Management/Sacramento River Flow Augmentation						Note: average annual costs on the order of \$12M to \$18M for purchase of water.

Assumptions:

Mobilization and demobilization, bond, permits, and insurance, and overhead and profit markups are included in each of the cost estimates. However, contractor markups (overhead and profit) are excluded in the Moffatt & Nichol, Flooded Islands Pre-Feasibility Study (for DWR), presentation, "Salinity Control Gate Concept Cost Analysis." To account for this, a 20 percent contractor markup is added. All cost estimates include the cost of access roads, boat lock if applicable, gate structure, and control structure. No O&M or removal and/or relocation cost are included in the cost estimates. Costs escalated to 2010 using Reclamation's Construction Cost Trends composite trend. Average from 2005 through 2008 used to escalate to 2009 and 2010.

TABLE 8-21
Summary of NoCDIS Alternatives Comparison

Alternatives	Comparison Criteria				
	Effectiveness: Water Quality Objective % decrease annual avg EC (Banks/Jones)	Effectiveness: Fish Objective	Completeness	Efficiency	Acceptability
A: Operable Gates on West False River	Low 4.8/3.6	Potential benefits to fish but possibly too small to quantify when gates operated primarily for water quality purposes.	Relatively complete—implementation would result in benefits to water quality and fish.	Cost Range: \$35M–\$110M	High. May be complementary to other Delta improvement implementation plans. May be operated for fish benefits (e.g., Delta smelt) when water quality operations do not govern.
D: Operable Gates on Three Mile Slough	Moderate 7.7/5.3	Potential benefits to fish but possibly too small to quantify when gates operated primarily for water quality purposes.	Relatively complete—implementation would result in benefits to water quality and fish.	Cost Range: \$75M	High. May be complementary to other Delta improvement implementation plans. May be operated for fish benefits (e.g., Delta smelt) when water quality operations do not govern.
E1: Through-Delta Facility	Highest ranking 15.2/10.5	Significant benefits to fish.	Relatively complete—implementation would result in benefits to water quality and fish.	Cost Range: \$540M	Low. This alternative is not complementary to the four Conservation Strategy Options under evaluation by BDCP participants including Reclamation. The CALFED 4,000 cfs TDF concept has been replaced by other similar proposals that are larger in capacity and length.
F1: DCC Modifications and Re-operation	Moderate 9.0/6.3	Relatively little benefit to fish.	Incomplete due to inability to meet fish objective.	Cost Range: \$230M + (significant dredging and levee modification costs)	Low. Whether the DCC can be modified without impacting adjacent land uses to be determined. More rigorous exercise of existing gates requires additional investigation. Re-operation concepts require more biological study prior to implementation. Downstream levee improvements for hydraulic capacity would require significant costs.
F2: DCC Re-operation	Low 3.1/1.9	Relatively little benefit to fish.	Incomplete due to inability to meet fish objective.	Cost Range: Higher annual O&M costs to be determined if carried forward	Moderate. More rigorous exercise of existing gates requires additional investigation.
G: Mokelumne River Water Exchange	Low 1.4/1.0	No benefit to fish due to timing of operations that corresponds to times of low fish presence.	Incomplete due to inability to meet fish objective.	Cost Range: undetermined It is expected that a cost surcharge on the water to make the exchange to acceptable by EBMUD for potential additional water treatment costs by using Sacramento River and for limiting their flexibility in water sources.	Low. This alternative has benefits, but the benefits are too few to make major improvements in the Delta. Would also require cooperation from EBMUD, which has not been involved with this alternative development to date.
H: Outflow Management/ Sacramento River Flow Augmentation	Low 3.1/2.2	No benefit to fish due to timing of operations that corresponds to times of low fish presence.	Incomplete due to inability to meet fish objective.	Cost Range: \$12M–\$18M for the annual purchase of water	Low. This alternative would require annual cooperation or long-term transfer agreements to make water available for Delta outflow management. This alternative is not likely acceptable to water users north of Delta.

Initial Alternatives Screening

Summary of Screening Process

This IAIR documents the development of a range of initial alternatives based on various measures identified to meet the planning objectives. This process of developing planning objectives, measures to meet these objectives, and combining the various measures into a range of possible alternatives is described in prior chapters. Following this process, Chapter 8 presents a preliminary evaluation of how each of the alternatives meets the screening criteria of effectiveness, efficiency, acceptability, and completeness as summarized in Table 8-21. The decision to carry an initial alternative forward for detailed consideration, as part of the NoCDIS, is based on the ability of the alternative to meet the NoCDIS planning criteria.

A more detailed screening analysis is a key part of the next phase of the federal planning process (the Plan Formulation phase, see Chapter 11). The preliminary screening evaluation in Chapter 8 of this report, however, provides sufficient information to allow several of the initial alternatives to be removed from further consideration in the NoCDIS planning process. This ensures that the resources allocated to the next phase of the analysis are focused on those alternatives that have the greatest opportunity to be successfully implemented. A summary of the IAIR conclusions for screening follows.

- Alternative A (Operable Gates on West False River), and Alternative D (Operable Gates on Three Mile Slough) and are carried forward into the next phase of the NoCDIS planning process.
- Alternative E1 (Through-Delta Facility), Alternative F1 (DCC Modifications and Re-operation), Alternative F2 (DCC Re-operation), Alternative G (Mokelumne River Water Exchange), and Alternative H (Outflow Management/ Sacramento River Flow Augmentation) are not carried forward for additional consideration in combination with the NoCDIS. In addition, the other alternatives screened in Chapter 7 (Alternatives B1, B2, C, and F2) are not carried forward for additional consideration.

The reasons for these recommendations are summarized in the following sections.

Alternative A – Operable Gates on West False River – CARRY FORWARD

Alternative A (Operable Gates on West False River) has been determined to meet the screening criteria for the reasons described in Chapter 8.

- The effectiveness of the West False River alternative is considered low when compared to other alternatives—the salinity decrease at the Banks and Jones Pumping Plants is expected to be on the order of 4.8 and 3.6 percent, respectively. Benefits to fish may be too small to measure based on the operations as defined in the IAIR, but the fish benefit may increase with minor alterations in the planned operational patterns (an action currently being considered by DWR in its project development process and also expected to be evaluated in the NoCDIS PFR). However, these benefits can be achieved for a relatively small investment.
- The alternative is relatively complete—operable gates on West False River have the ability to benefit both water quality and fish, especially given the alterations being considered by DWR in its project development process.
- The alternative appears to be efficient. Although the economic benefits require further study, it appears that the benefits to fish and the benefits resulting from water quality improvement can be realized with a limited investment of resources.
- The alternative meets the acceptability criteria based on its level of development by DWR (with stakeholder support) and because it is perceived by many as complementary to larger-scale actions in the Delta for water quality and fish improvements (e.g., Delta Vision, BDCP). Additionally, implementation of Alternative A is considered a near-term action for Delta improvement when compared to other alternatives.

The completeness of this alternative, its apparent efficiency (cost-effectiveness in meeting the planning objectives), and its acceptability with agency participants and other stakeholders warrants further consideration in the next phase of the planning process. In addition, it is possible that minor modifications to the operational patterns could increase the effectiveness of this alternative for fish—this warrants further study.

Alternative D – Operable Gates on Three Mile Slough – CARRY FORWARD

Alternative D (Operable Gates on Three Mile Slough) has been determined to meet the screening criteria for the reasons described in Chapter 8.

- The effectiveness of the Three Mile Slough alternative is considered moderate—the salinity decrease at the Banks and Jones Pumping Plants is expected to be on the order of 7.7 and 5.3 percent, respectively. Benefits to

fish may be too small to measure based on the operations as defined in the IAIR, but the fish benefit may increase with minor alterations in the planned operational patterns (an action currently being considered by DWR in its project development process).

- The alternative is relatively complete—operable gates on Three Mile Slough have the ability to benefit both water quality and fish, especially given the alterations being considered by DWR in its project development process.
- The alternative appears to be efficient. Although the economic benefits require further study, it appears that the benefits to fish and the benefits resulting from water quality improvement can be realized with a limited investment of resources.
- The alternative meets the acceptability criteria based on its level of development by DWR (with stakeholder support), and because it is perceived by many as complementary to larger-scale actions in the Delta for water quality and fish improvements (e.g., Delta Vision, BDCP). Additionally, implementation of Alternative D is considered a near-term action for Delta improvement when compared to other alternatives.

The effectiveness of the Three Mile Slough alternative in meeting the planning objective for water quality, together with the apparent ability of the alternative to be implemented within a short timeframe, warrants further consideration in the next phase of the planning process. In addition, it is possible that minor modifications to the operational patterns could increase the effectiveness of this alternative for fish—this warrants further study.

Alternative E1 – Through-Delta Facility – DO NOT CARRY FORWARD

Alternative E1 (Through-Delta Facility) has been determined to not meet the screening criteria of the NoCDIS for the reasons described in Chapter 8.

- The effectiveness of the TDF alternative is the highest of all alternatives considered—the salinity decrease at the Banks and Jones Pumping Plants is expected to be on the order of 15.2 and 10.5 percent, respectively. Benefits to fish also are high given the alternative’s ability to help limit fish movement into the central Delta.
- The alternative is relatively complete—a TDF has the ability to benefit both water quality and fish.
- The alternative does not appear to be efficient. Although the TDF ranks the highest in terms of effectiveness, it is unclear that the marginal increase in benefits relative to the other alternatives warrants the substantially higher cost.
- The alternative does not meet the acceptability criteria due to possible duplication with ongoing long-term Delta planning efforts. The original

concept of the TDF as envisioned in the CALFED ROD (and described in this Study) stopped at the Mokelumne River because of study area considerations. However, in the BDCP and the Delta Vision process, this alternative has been replaced by larger facilities that are currently being considered, and that approach the export pumps, as they do not have the same study area restrictions. Given the high level of development of the new Delta conveyance actions and the agency and stakeholder resources dedicated to their study, Reclamation intends to complete the TDF Study authorization as part of or in coordination with these other Delta conveyance actions.

This alternative is not carried forward for additional study as part of the NoCDIS planning process.

Alternative F1 – DCC Modifications and Re-operation – DO NOT CARRY FORWARD

Alternative F1 (DCC Modifications and Re-operation) has been determined to not meet the screening criteria of the NoCDIS for the reasons described in Chapter 8.

- The effectiveness of this alternative is considered moderate—the salinity decrease at the Banks and Jones Pumping Plants is expected to be on the order of 9.0 and 6.3 percent, respectively. The overall effectiveness, however, is tempered by the limited fish benefit expected.
- The alternative is not complete. Modifications and re-operation of the DCC only provides water quality benefits. The alternative provides little to no fish benefits.
- The alternative does not appear to be efficient. A substantial investment would be required in order to achieve moderate water quality benefits and little to no fish benefits.
- The alternative does not meet the acceptability criteria due to possible duplication with ongoing long-term Delta planning efforts. The larger facilities currently being considered in the BDCP and by the Delta Vision process are being developed for a similar purpose—ensuring that an appropriate amount of Sacramento River water is routed toward the south Delta. In addition, it is unclear if it is possible to construct such an alternative without substantial impacts to land uses adjacent to existing gates. Reclamation intends to complete the DCC Study authorization as part of or in coordination with these other Delta conveyance actions.

This alternative is not carried forward for additional study as part of the NoCDIS planning process.

Alternative F2 – DCC Re-operation – DO NOT CARRY FORWARD

Alternative F2 (DCC Re-operation) has been determined to not meet the screening criteria of the NoCDIS for the reasons described in Chapter 8.

- The effectiveness of this alternative is considered low when compared to other alternatives—the salinity decrease at the Banks and Jones Pumping Plants is expected to be on the order of 3.1 and 1.9 percent, respectively. Relatively few fish benefits are expected. However, these benefits can be achieved for a relatively small investment.
- The alternative is not complete. Re-operation of the DCC provides only limited water quality benefits. The alternative provides little to no fish benefits.
- The alternative appears to be efficient. Although the water quality benefits are expected to be low, they could be achieved with only minor changes in existing DCC operations and maintenance costs. No significant capital costs are expected with the implementation of re-operation of the DCC.
- The alternative does not meet the acceptability criteria as an independent alternative for the NoCDIS. Although considering minor changes in DCC operations is expected to be acceptable to agencies and most stakeholders, additional studies are warranted to ensure water quality goals can be met without adverse effects to fish. Reclamation intends to complete the DCC Study authorization as part of or in coordination with other Delta conveyance actions currently being considered in the BDCP and by the Delta Vision process.

This alternative is not carried forward for additional study as part of the NoCDIS planning process.

Alternative G – Mokelumne River Water Exchange – DO NOT CARRY FORWARD

Alternative G (Mokelumne River Water Exchange) has been determined to not meet the screening criteria for the reasons described in Chapter 8.

- The effectiveness of this alternative is considered low—the salinity decrease at the Banks and Jones Pumping Plants is expected to be on the order of 1.4 and 1.0 percent, respectively. No fish benefits are expected.
- The alternative is not complete in that it provides very limited water quality benefits and no fish benefits.
- It is unclear whether or not this alternative would be efficient. Benefits appear limited, but cost information is not known.

- The acceptability of this alternative is considered low compared to the other alternatives. Implementing this alternative would require the participation of the EBMUD, which has not been involved in developing this alternative.

For the reasons described previously, this alternative is not carried forward for additional study as part of the NoCDIS planning process.

Alternative H – Outflow Management/Sacramento River Flow Augmentation – DO NOT CARRY FORWARD

Alternative H (Outflow Management/Sacramento River Flow Augmentation) has been determined to not meet the screening criteria for the reasons described in Chapter 8.

- The effectiveness of this alternative is considered low—the salinity decrease at the Banks and Jones Pumping Plants is expected to be on the order of 3.1 and 2.2 percent, respectively. No fish benefits are expected.
- The alternative is not complete in that it provides limited water quality benefits and no fish benefits.
- It is unclear whether or not this alternative would be efficient due to the uncertainties of purchasing water (both availability and costs). Costs involve the annual purchase of water from the Sacramento Valley each year and benefits appear limited.
- The acceptability of this alternative is considered low compared to the other alternatives. Implementing this alternative would require long-term transfer agreements involving SWP and CVP contractors, who have not been involved in developing this alternative.

For the reasons described previously, this alternative is not carried forward for additional study as part of the NoCDIS planning process.

Federal Interest

Reclamation’s participation in the project could result in improved water quality, which could enhance water supply reliability for CVP contractors. In addition, the project could provide increased opportunities to protect, restore, and enhance fish populations. At this time, these are identified as potential benefits based on the preliminary analysis summarized in this IAIR. The degree and magnitude of the federal interest and the allocation of costs between the federal government and non-federal partners will be determined in the future NoCDIS Feasibility Report.

Public Involvement and Study Management

Public Involvement Program

Effective public involvement will be an integral component to the NoCDIS planning activities.

Effective Public Involvement Plans (PIP) are designed to involve stakeholders and the public in the planning and decision making process—with communication targeted to those who have an interest in the project. Project development will be communicated in a focused, factual, consistent, and timely fashion. In addition, communications must be regular and consistent to integrate effectively with the many other messages and issues that will be raised throughout the project's development.

This PIP describes the communication strategies and activities that the Project Management Team will employ to ensure public and stakeholder participation and awareness throughout the NoCDIS planning process. A critical component of the PIP will include coordinating communication efforts with other ongoing Delta efforts such as DWR's Franks Tract Project and Delta Cross Channel studies.

Communication Goals and Objectives

The public outreach goals for the NoCDIS are intended to meet planning and environmental compliance requirements, and are designed to identify and inform stakeholders, and gain public input early in the project.

The following objectives are designed to meet those goals and facilitate an efficient public involvement process.

- Communicate the need of the project clearly and openly.
- Provide information to the public and stakeholders that is comprehensive, easy to understand, and disseminated in an effective and timely manner.
- Engage the public and stakeholders in open and constructive dialogue regarding project development.
- Provide a clear description of alternatives.
- Provide opportunities to the public and stakeholders to participate and contribute to the process.
- Facilitate effective communication among decision makers, the Project Management Team, stakeholders, and the public.

- Provide technical information that is understandable.
- Be cognizant of, understand, and appropriately address public issues and concerns.
- Identify and address potential issues of concern.

Stakeholder Identification and Assessment

The primary initial outreach strategy is to identify stakeholders and their key issues and concerns to help tailor all NoCDIS outreach activities. A database/ mailing list will be developed and updated to ensure the following interested stakeholders and individuals are informed and up-to-date.

- Elected officials
- Federal agencies
- State agencies
- Local government agencies
- Native American Tribes
- Business interests
- Agricultural interests
- Environmental interests
- Nongovernmental organizations
- Environmental justice communities
- Interested public

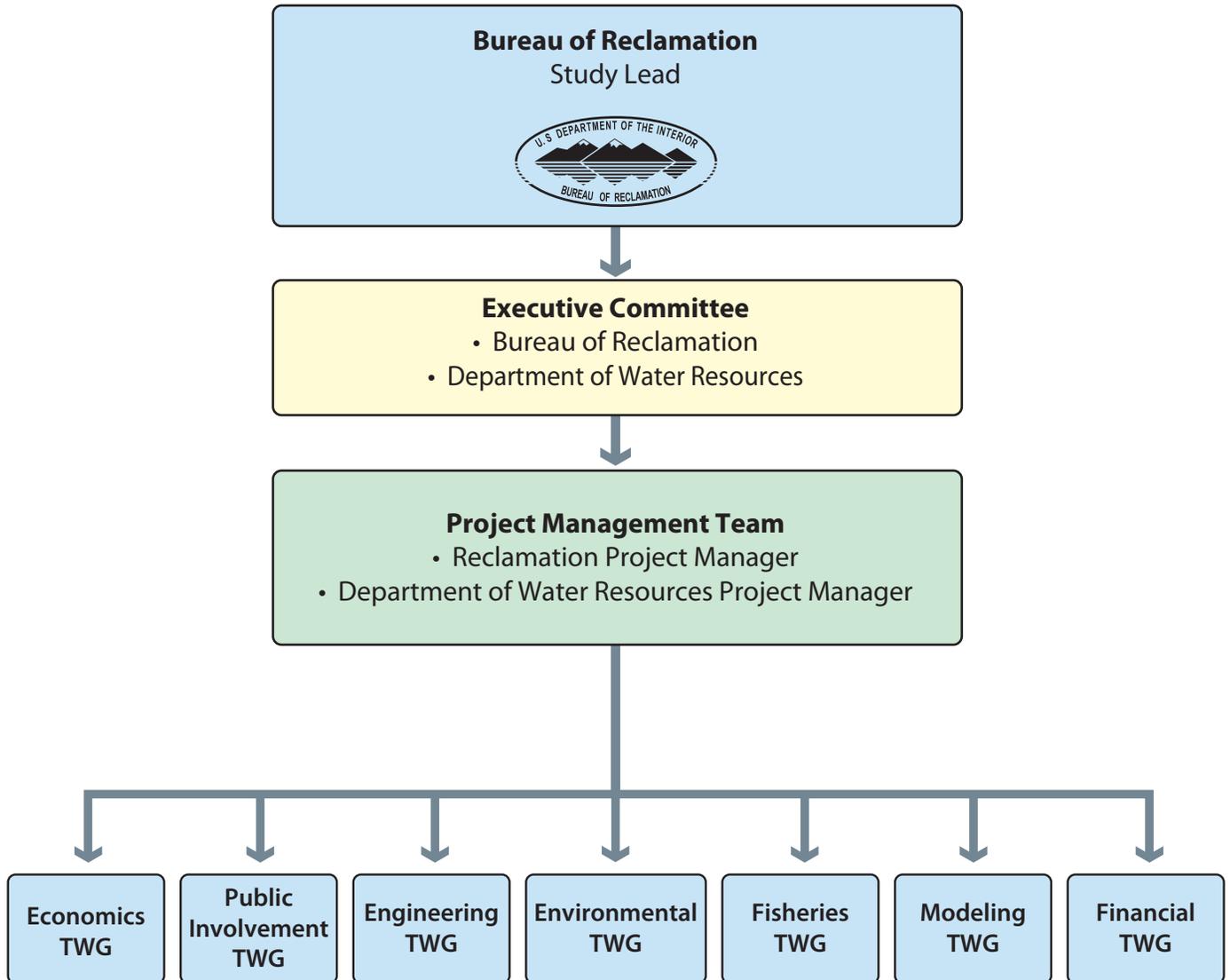
Study Management

All aspects of Study administration are the responsibility of Reclamation, including the timely submission of all planning documentation to Reclamation management. DWR is the lead CEQA agency and non-federal cost share partner. The Study is administered through the Executive Committee, Project Management Team, and Technical Working Groups (TWGs). The components of the NoCDIS management structure are described as follows and presented in the organization chart in Figure 10-1.

Executive Committee

The Executive Committee includes management-level representatives from Reclamation and DWR, and is responsible for providing resources and policy guidance to the Project Management Team when necessary. Reclamation's project manager participates on the Executive Committee to provide the necessary link to the Project Management Team. It is the responsibility of Reclamation's project manager to ensure adequate information is passed between the Project Management Team and the Executive Committee, and that issues are identified and guidance is sought at the earliest possible opportunity.

North/Central Delta Improvement Study



Note: TWG = Technical Working Group.

FIGURE 10-1
ORGANIZATIONAL CHART
INITIAL ALTERNATIVES INFORMATION REPORT,
NORTH/CENTRAL DELTA IMPROVEMENT STUDY

This page intentionally left blank.

Project Management Team

The Project Management Team is responsible for the day-to-day activities of the Study, and is made up of representatives from Reclamation and DWR.

U.S. Department of the Interior, Bureau of Reclamation

As the federal sponsor of the Study, Reclamation must ensure that the Study process is in accordance with the Principles and Guidelines, Reclamation law, NEPA, and all applicable Reclamation guidelines. Reclamation's project manager is responsible for coordinating the necessary studies. Study decision making authority rests with Reclamation's Executive Committee members.

California Department of Water Resources

DWR is responsible for ensuring compliance with CEQA and all applicable state and local regulations. As the local cost-share partner, DWR has provided a project manager to participate on the Project Management Team, and funds the activities associated with its participation in the Feasibility Study and environmental documentation.

Technical Work Groups

It is the TWG's responsibility to perform the required analyses for the Feasibility Study, including environmental documentation.

- Economics TWG provides the necessary information to fully assess the national and regional economic benefits and other social information relevant to the Study.
- Public Involvement TWG works with the various TWGs to ensure a consistent message is being provided to the public regarding various aspects of the NoCDIS.
- Engineering TWG is responsible for studying physical improvements necessary for the project.
- Environmental TWG is responsible for coordinating with other TWGs to define the existing conditions as well as any environmental impacts associated with various alternatives.
- Fisheries TWG is responsible for providing the necessary information about impacts of the project on Delta fisheries.
- Modeling TWG coordinates the various models used for the Feasibility Study. This group works closely with the Engineering and Environmental TWGs to ensure consistency in the modeling approaches that are being used to assess impacts for the various alternatives.
- Financial TWG is responsible for financial issues of the project including cost allocation and ability to pay.

These TWGs are led by a member of the Project Management Team to ensure adequate communication between the TWGs and the Project Management Team.

Study Coordination

Reclamation's project manager is responsible for all aspects of Study coordination, including providing adequate resources to the various Study teams and conducting regularly scheduled Project Management Team meetings. The project manager is also responsible for maintaining the Study schedule and budget, ensuring timely dissemination of information to the public, scheduling public participation, and ensuring quality of the Study. It will be necessary to continue both coordination and communication with the various TWGs so that the necessary studies are performed efficiently and at the proper time. It is also important that the TWG leaders provide information to the Project Management Team and Project Manager to address issues that arise in a timely manner. Figure 10-1 conceptually depicts the Study management organization.

Next Steps

As described in Chapter 9, two alternatives will be carried forward: Alternative A (Franks Tract, Operable Gates on West False River) and Alternative D (Franks Tract, Operable Gates on Three Mile Slough). This chapter provides the framework for the next steps beyond the IAIR for the NoCDIS federal planning process.

Next Steps

The key milestones for the federal planning process, as well as the CEQA process, are listed as follows.

- NOI/NOP
- PFR (Draft and Final)
- Feasibility Report (Draft and Final)
- EIS/EIR (Draft and Final)
- ROD/Notice of Determination (NOD)

Next Steps for the Plan Formulation Report

The next step in the federal planning process is the preparation of the PFR. As described in Chapter 5, the purpose of the PFR is to take the screening results from the initial alternatives, refine specific alternative plans to address the planning objectives; evaluate, coordinate, and compare the plans; and identify a preliminary NED plan. The following immediate next steps are expected to support the plan formulation phase.

- Perform a preliminary update of the costs, economic benefits, and accomplishments of alternatives carried forward from the IAIR. All engineering and cost updates will be coordinated with the efforts of DWR's ongoing Franks Tract Study. Analysis will include additional water quality and Particle Tracking Modeling with emphasis on facility operations optimized for fish benefits. The initial alternatives carried forward will be developed into more comprehensive alternatives. As such, more details will be defined on specific locations of alternatives, facility configurations, geotechnical requirements, ancillary facilities, and necessary levee or adjacent land modifications.
- Identify likely residual information needs to refine the without-project conditions for inclusion in the draft and final feasibility reports.
- Complete a preliminary site-specific analysis of potential physical, environmental, socioeconomic, and cultural effects of the comprehensive

alternatives. The comprehensive alternatives will be refined to include the appropriate compensation measures identified during this analysis.

- Evaluate the performance of the refined comprehensive alternatives using principles and constraints identified and developed in the IAIR and supplemental information.
- Compare and screen the alternatives using criteria consistent with Economic and Environmental Principles and Guidelines Water and Land Resources Implementation Studies and established federal policies and practices in water resources planning.
- Prepare the draft and final PFR. The PFR will provide details on the costs, benefits, and accomplishments of each refined complete alternative and results of the screening process.

Study Schedule

The conceptual progression of tasks in the federal planning process is provided in Figure 11-1. This schedule demonstrates the amount of time and approximate relationship of the various studies that will need to be accomplished for the NoCDIS Feasibility Study and environmental documentation. The schedule is subject to continued appropriations and study results and may be updated as the study progresses. Information from the NOI/NOP and public scoping sessions are being used to complete the PFR and begin work on the Feasibility Report and EIS/EIR.

Commencement of the engineering, economic, and environmental studies will overlap preparation of the PFR and Feasibility Report so that an iterative approach to choosing the best alternative can be used. It is anticipated that the documentation for the NoCDIS could be completed by mid-2011.

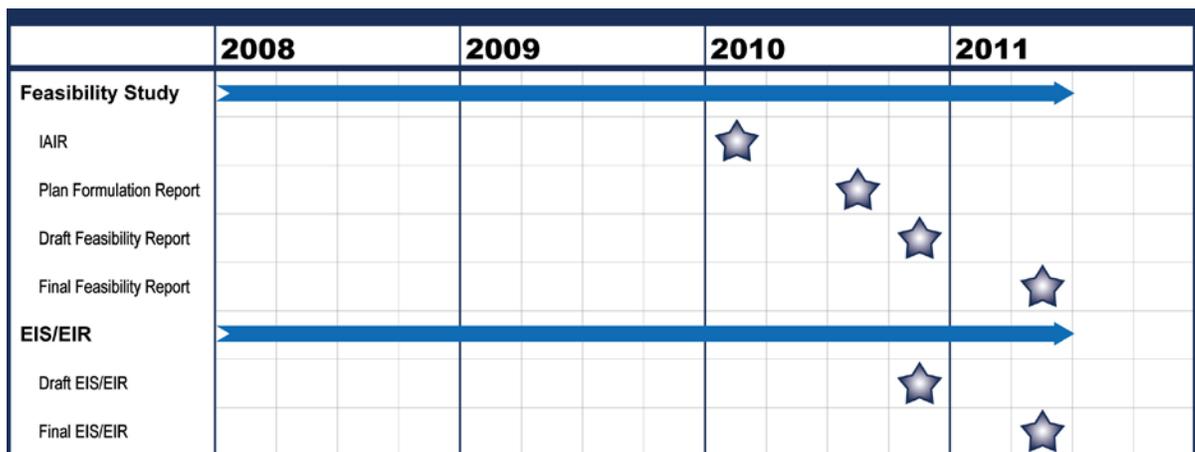


FIGURE 11-1
Study Schedule

References

- 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. Department of the Interior, Water and Power Resources Service. Sacramento, CA.
- Baggett, A., Jr. 2005. Triennial Review: Comments of the Bay Institute on Export Limits. January 18. Power Point Presentation. Periodic Review of the 1995 Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary.
- Baker, P. T., T. P. Speed, and F. K. Ligon. 1995. “Estimating the Influence of Temperature on the Survival of Chinook Salmon Smolts Migrating through the Sacramento–San Joaquin River Delta of California.” *Canadian Journal of Fisheries and Aquatic Science*. 52: 855–863.
- Barnhart, R. A. 1986. *Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Pacific Southwest)—Steelhead*. June. (Biological Report 82 [11.60], TREL-82-4.) U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, Coastal Ecology Group, Waterways Experiment Station. Slidell, LA.
- Baxter, R. 1999. Osmeridae. Pages 179–216 in J. Orsi, editor. *Report on the 1980–1995 Fish, Shrimp, and Crab Sampling in the San Francisco Estuary, California*. California Department of Fish and Game, Technical Report 63, Stockton. Available: www.estuaryarchive.org/archive/orsi_1999/.
- Bay Delta Conservation Plan Steering Committee. 2007. *Strategic Evaluation*. October 2007.
- Bay Delta Conservation Plan Steering Committee. 2007a. *Conservation Strategy Options Evaluation Report*. Available online: www.resources.ca.gov/bdcp. September 17.
- Bay Delta Conservation Plan Steering Committee. 2007b. Points of Agreement for Continuing into the Planning Process. Available online: www.resources.ca.gov/bdcp. November 16.
- Bjornn, T. C. and D. W. Reiser. 1991. “Habitat Requirements of Salmonids in Streams,” pp. 83–138. In Meehan, W. R. (ed.), *Influences of Forest and Rangeland Management on Salmonid Fishes and their Habitats*. American Fisheries Society Special Publication 19. Bethesda, Maryland: American Fisheries Society. 751 pp.

Chapter 12: References

- Bloom, N. S. 1992. "On the Chemical Form of Mercury in Edible Fish and Marine Invertebrate Tissue." *Canadian Journal of Fisheries and Aquatic Sciences*. 49: 1010-1017. Bodaly and Fudge. 1999.
- Bodaly, R. A. and R. J. P. Fudge. 1999. "Uptake of Mercury by Fish in an Experimental Boreal Reservoir." *Archives of Environmental Contamination and Toxicology*. 37: 103-109.
- Brandes, P. L. and J. S. McLain. 2001. Juvenile Chinook salmon abundance, distribution, and survival in the Sacramento–San Joaquin Estuary. Fish Bulletin 179, Contributions to the Biology of Central Valley Salmonids, Volume 2. Edited by R. L. Brown. California Department of Fish and Game, Sacramento, CA.
- Brown, Randall L. 2001. "Fish Bulletin 179. Contributions to the Biology of Central Valley Salmonids. Volumes 1 & 2." Scripps Institution of Oceanography Library. Fish Bulletin: 179. September 1. <http://repositories.cdlib.org/sio/lib/fb/179>.
- Burton, Jr. and J. Cairns, Jr. (eds.). *Handbook of Ecotoxicology, 2nd Edition*. CRC Press, Boca Raton, Florida. pp. 409-463.
- CALFED Bay–Delta Program. 1996. *Affected Environment Technical Report, Cultural Resources in the Delta Region*. Draft. September.
- CALFED Bay–Delta Program. 2000. *Final Programmatic Environmental Impact Statement/Environmental Impact Report, CALFED Bay–Delta Program*. Prepared for the U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, National Marine Fisheries Service, U.S. Environmental Protection Agency, Natural Resources Conservation Service, U.S. Army Corps of Engineers, and California Resources Agency. July. Sacramento, CA.
- California Department of Fish and Game (CDFG). 2008. Delta Smelt for the San Francisco Bay and Estuary. Available online: www.delta.dfg.ca.gov/baydelta/monitoring/delta.asp. Accessed April 2008.
- California Department of Fish and Game (CDFG). 2008b. Longfin Smelt in the San Francisco Bay. Available online: www.delta.dfg.ca.gov/baydelta/monitoring/lf.asp. Accessed April 2008.
- California Department of Parks and Recreation. 1997. Sacramento-San Joaquin Delta Recreation Survey (includes boating survey results and fishing survey results). Prepared for the Delta Protection Commission and the California Department of Boating and Waterways. September.
- California Department of Water Resources (DWR). 1993. *Sacramento–San Joaquin Delta Atlas*. Sacramento, CA.

- California Department of Water Resources (DWR). 1994a. *Five-Year Report of the Municipal Water Quality Investigations Program*. Division of Local Assistance. November. Sacramento, CA.
- California Department of Water Resources (DWR). 1994b. *Summary of Sensitive Plant and Wildlife Resources in Suisun Marsh during Water Years 1984–1994*. Sacramento, CA.
- California Department of Water Resources (DWR). 1995. *Water and Sediment Quality Study for the Interim South Delta Program*. May. Sacramento, CA.
- California Department of Water Resources (DWR). 2003. California's Groundwater—Bulletin 118. Last revised: April 14, 2003. Available online: www.waterplan.water.ca.gov/groundwater/118index.htm. Accessed: May 16, 2003.
- California Department of Water Resources (DWR). 2005. *Flooded Islands Pre-Feasibility Study Report*. June 30.
- California Department of Water Resources (DWR). 2006. *South Delta Improvement Project (SDIP) Environmental Impact Report/ Statement*. December.
- California Department of Water Resources (DWR). 2007. *Franks Tract Value Engineering Study*. June 2007.
- California Department of Water Resources (DWR). 2007a. *Value Engineering Study Report, Franks Tract Pilot Project*. Prepared by Strategic Value Solutions, Inc. June.
- California Department of Water Resources (DWR). 2007b. *Through-Delta Facility Pre-Feasibility Study*. March.
- California Department of Water Resources and Bureau of Reclamation. 1994. *Effects of the Central Valley Project and State Water Project on Delta Smelt and Sacramento Splittail*. Biological Assessment. Prepared for U.S. Fish and Wildlife Service, Ecological Services, Sacramento Field Office. Sacramento, California.
- California Employment Development Department, Labor Market Information Division. 2002a. County snapshot San Joaquin County 2002a. August.
- California Employment Development Department, Labor Market Information Division. 2002b. County snapshot Contra Costa County 2002b. August.
- California Employment Development Department, Labor Market Information Division. 2002c. County snapshot Alameda County 2002c. August.
- Clarkson, T. W. 2002. “The Three Modern Faces of Mercury.” *Environmental Health Perspectives*. 110 (Supplement 1): 11-23.

- Cramer, S. P. 1996. The Status of Late-Fall and Spring Chinook Salmon in the Sacramento River Basin in Regards to the Endangered Species Act. S. P. Cramer & Associates. 39 pp. (Available from S. P. Cramer & Associates, Inc., 300 S.E. Arrow Creek Lane, Gresham, OR 97080.)
- Delta Protection Commission. 1995. Land Use and Resource Management Plan for the Primary Zone of the Delta. Adopted February 23, 1995. Available online: <<http://www.delta.ca.gov/plan.html>.
- Delta Protection Commission. 1997. Summary of the “Sacramento–San Joaquin Delta Recreation Survey, prepared by the Department of Parks and Recreation for the Delta Protection Commission and the Department of Boating and Waterways.” Available online: www.delta.ca.gov/recur.html#_chapI. Accessed September 30, 2002.
- Delta Smelt Working Group (DSWG). 2007. Briefing Statement: Recommendations for Spring Action. Memorandum to the Water Operations Management Team, May 15, 2007.
- Fredrickson, D. A. 1973. Early Cultures of the North Coast ranges, California. Ph.D. dissertation. University of California, Davis.
- Grieb, T. M., C. T. Driscoll, S. P. Gloss, C. L. Schofield, G. L. Bowie, and D. B. Porcella. 1990. “Factors Affecting Mercury Accumulation in Fish in the Upper Michigan Peninsula.” *Environmental Toxicology and Chemistry*. 9: 919-930.
- Grimaldo, L., C. Peregrin, and R. Miller. 2000. Examining the Relative Predation Risks of Juvenile Chinook Salmon in Shallow Water Habitat: The Effect of Submerged Aquatic Vegetation. Interagency Ecological Program for the San Francisco Estuary, California Department of Water Resources, Sacramento, CA. Winter. IEP Newsletter. 13(1): 57–61.
- Hall, B. D., D. M. Rosenberg, and A. P. Wiens. 1998. “Methyl Mercury in Aquatic Insects from an Experimental Reservoir.” *Canadian Journal of Fisheries and Aquatic Sciences*. 55: 2036-2047. <http://calwater.ca.gov/science/pdf/MercuryStrategyFinalReport.pdf>.
- Hall, B. D., V. L. St. Louis, K. R. Rolfhus, R. A., Bodaly, K. G. Beaty, M. J. Paterson, and K. A. Peech-Cherewyk, K.A. In press. “Impacts of Reservoir Creation on the Biogeochemical Cycling of Methyl and Total Mercury in Boreal Upland Forests.” *Ecosystems*.
- Hallock, R. J., R. T. Elwell, and D. H. Fry. 1970. “Migrations of Adult King Salmon (*Oncorhynchus tshawytscha*) in the San Joaquin Delta as Demonstrated by the Use of Sonic Tags.” *California Department of Fish and Game, Fish Bulletin*. 151: 1-192.
- Hallock, R. J. and F. W. Fisher. 1985. *Status of the Winter-run Chinook Salmon (Oncorhynchus tshawytscha) in the Sacramento River*. Anadromous

- Fisheries Branch Office Report. Sacramento: California Department of Fish and Game.
- Hallock, R. J. 1989. *Upper Sacramento River Steelhead Oncorhynchus mykiss, 1952–1988*. A report to the U.S. Fish and Wildlife Service. September 15.
- Healey, M. C. 1991. “Life History of Chinook Salmon (*Oncorhynchus tshawytscha*).” Pages 311–393 in C. Groot and L. Margolis (eds.), *Pacific Salmon Life Histories*. Vancouver, British Columbia: University of British Columbia Press.
- Hecky, R. E., D. J. Ramsey, R. A. Bodaly, and N. E. Strange. 1991. “Increased Methylmercury Contamination in Fish in Newly Formed Freshwater Reservoirs.” in Suzuki T., et al. (Eds.), *Advances in Mercury Toxicology*. Plenum Press, New York, pp. 33-52.
- Heinz, G. 2003. *Use of Egg Injections to Rank the Sensitivities of Avian Embryos to Methylmercury*. Final Report to the California Bay Delta Authority. 29 pp. (<http://loer.tamug.tamu.edu/calfed/FinalReports.htm>).
- Hoffman, D. J., H. M. Ohlendorf, C. M. Marn, and G. W. Pendelton. 1998. “Association of Mercury and Selenium with Altered Glutathione Metabolism and Oxidative Stress in Diving Ducks from the San Francisco Bay Region, USA.” *Environmental Toxicology and Chemistry*. 17: 167-172.
- IEP Database. IEP (Interagency Ecological Program for the San Francisco Estuary). 2006. Interagency Ecological Program Synthesis of 2005 Work to Evaluate the Pelagic Organism Decline (POD) in the Upper San Francisco Estuary. Available at: http://science.calwater.ca.gov/pdf/workshops/IEP_POD_2005WorkSynthesis-draft_111405.pdf.
- Interagency Ecological Program for the San Francisco Estuary (IEP). 2008. Sampling in the Freshwater Reaches of the Lower Delta for the Sediment Quality Objectives Measures. Lowe, S.; Salop, P.; Gehrts, K.; Anderson, B.; Phillips, B. M.; Bay, S. (Eds.).
- Jackson, T. A. 1992. Microhabitat Utilization by Juvenile Chinook Salmon (*Oncorhynchus tshawytscha*) in Relation to Stream Discharges in the Lower American River of California. M.S. thesis, Oregon State University. 118 pp.
- Kelley, J. T., A. P. Klimley, and C. E. Crocker. 2003. Movements of Adult and Sub-Adult Green Sturgeon (*Acipenser medirostris*) in the San Francisco Estuary. 6th Biennial State of the Estuary Conference. Oakland, CA. Web site: http://biotelemetry.ucdavis.edu/pages/bio_kelly.htm.
- Kimmerer, Boyer, Marvin-DiPasquale, Nobriga, Sereno, Thompson. 2005. Ecological Consequences of Elevated Salinity in the Sacramento-

- San Joaquin Delta (proposal submitted to CALFED Science Program). 2005.
- Kimmerer, Wim J. and M. L. Nobriga. 2008. "Investigating Particle Transport and Fate in the Sacramento-San Joaquin Delta Using a Particle Tracking Model." *San Francisco Estuary and Watershed Science*. Vol. 6, Issue 1 (February), Article 4.
- Kroeber, A. L. 1976. *Handbook of the Indians of California*. New York, New York: Dover Publications. Reprint of 1925 edition, Bulletin 18, Bureau of American Ethnology, Smithsonian Institution, Washington, DC.
- Mahaffey, K. R. 2000. "Recent Advances in Recognition of Low-Level Methylmercury Poisoning." *Current Opinion in Neurology*. 13: 699-707.
- Marine, K. R. and D. A. Vogel. 2000. *Upstream Migration Monitoring at Woodbridge Dam during August 1999 through March 2000; Lower Mokelumne River Fisheries Monitoring Program*. Contract report prepared for East Bay Municipal Utility District by Natural Resource Scientists, Inc. September 2000. 48 p. plus appendices.
- Marine, K. M. 1997. Effects of Elevated Water Temperature on Some Aspects of the Physiological and Ecological Performance of Juvenile Chinook Salmon (*Oncorhynchus tshawytscha*): Implications for Management of California's Central Valley Salmon Stocks. Masters Thesis. University of California, Davis.
- McClurg, S. and G. Pitzer. 2007. *Water Education Foundation, Laypersons Guide to Drinking Water and the Delta*. ISBN 1-893246-21-3. 2007.
- McCullough, D. A. 1999. *A Review and Synthesis of Effects of Alterations to the Water Temperature Regime on Freshwater Life Stages of Salmonids, with Special Reference to Chinook Salmon*. Prepared for the U.S. Environmental Protection Agency, Region 10, Seattle, WA. Published as EPA 910-R-99-010. July 1999. 291 pp.
- McEwan, D. and T. A. Jackson. 1994. *Steelhead Management Plan for California*. California Department Fish and Game. (Available Environmental and Technical Services Division, NMFS, 911 N.E. 11th Avenue, Room 620, Portland, OR 97232.)
- McLain, J. unpublished. Southern Distinct Population Segment (DPS) Green Sturgeon Life History Table provided as a hand-out at the NMFS Green Sturgeon Public Scoping Workshop, Sacramento CA, June 1, 2006.
- Moffatt & Nichol. 2006. Presentation: "Salinity Control Gate Concept Cost Analysis." Presented to DWR for the Flooded Islands Feasibility Study on January 25.

- 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." *Transactions of the American Fisheries Society*. 121: 67–77.
- Moyle, P. B., R. M. Yoshiyama, J. E. Williams, and E. D. Wikramanayake. 1995. *Fish Species of Special Concern in California*. Second Edition. Final Report to the Department of Fish and Game, Inland Fisheries Division, Rancho Cordova, CA. June 1995.
- Moyle, P. B., R. Pine, L. R. Brown, C. H. Hanson, B. Herbold, K. M. Lentz, L. Meng, J. J. Smith, D. A. Sweetnam, and L. Winternitz. 1996. *Recovery Plan for the Sacramento–San Joaquin Delta Native Fishes*. U.S. Department of the Interior Fish and Wildlife Service, pp. 15–46.
- Moyle, P. B. 2002. *Inland Fishes of California*. Revised edition. University of California Press, Berkeley.
- Myrick, C. A. and J. J. Cech, Jr. 2001. Temperature Effects on Chinook Salmon and Steelhead: A review focusing on California's Central Valley populations. White paper. <http://www.sfei.org/modelingforum/>
- Newman, K. and J. Rice. 1997. *Statistical Model for Survival of Chinook Salmon Smolts Out-migrating through the Lower Sacramento–San Joaquin System*. Technical Report 59. Interagency Ecological Program for the San Francisco Bay/Delta Estuary. California Department of Water Resources, Sacramento, CA.
- National Marine Fisheries Service (NMFS). 1996. Factors for Decline: A supplement to the notice of determination for West Coast steelhead under the Endangered Species Act. Portland, OR.
- National Marine Fisheries Service (NMFS). 1998. A Primer for Federal Agencies—Essential Fish Habitat: New marine fish habitat conservation mandate for Federal agencies.
- National Research Council. Toxicological Effects of Methylmercury. 2000. Washington, DC. <http://www.nap.edu/openbook.php?isbn=0309071402>
- Nobriega, M. and P. Cadrett. 2001. Differences Among Hatchery and Wild Steelhead: Evidence from Delta Fish Monitoring Programs. Interagency Ecological Program for the San Francisco Estuary, Sacramento, CA. IEP Newsletter 14(3):30–38.
- Paterson, M. J., J. W. M. Rudd, and V. St. Louis. 1998. "Increases in Total and Methylmercury in Zooplankton Following Flooding of a Peatland Reservoir." *Environmental Science and Technology*. 32: 3868-3874.
- Pelagic Organism Decline Progress Report: 2007 Synthesis of Results. Randall Baxter (DFG), Rich Breuer (DWR), Larry Brown (USGS), Mike Chotkowski (USBR), Fred Feyrer (DWR), Marty Gingras (DFG), Bruce Herbold (USEPA), Anke Mueller-Solger (DWR), Matt Nobriega

- (CALFED), Ted Sommer (DWR), and Kelly Souza (DFG). January 15, 2008.
- Ragir, S. 1972. The early horizon in Central California prehistory. Contributions of the University of California Archaeological Research Facility No. 10. Berkeley, CA.
- Raleigh, R. F., T. Hickman, R. C. Soloman, and P. C. Nelson. 1984. *Habitat Suitability Information: Rainbow Trout*. Biological Report 82 [10.60]. U.S. Fish and Wildlife Service. Washington, D.C. (USFWS/OBS-82/10.60 64 pp.)
- Reynolds, F. L., T. Mills, R. Benthin, and A. Low. 1993. *Central Valley Anadromous Fisheries and Associated Riparian and Wetlands Areas Protection and Restoration Action Plan*. Draft. California Department of Fish and Game, Inland Fisheries Division. Sacramento, CA.
- Rich, A. A. 1987. *Report on Studies Conducted by Sacramento County to Determine Temperatures which Optimize Growth and Survival in Juvenile Chinook Salmon (Oncorhynchus tshawytscha)*. Sacramento: Prepared by McDonough, Holland, and Allen, Sacramento, CA.
- Schwarzbach, S. and T. Adelsbach. 2003. *Field Assessment of Avian Mercury Exposure in the Bay-Delta Ecosystem*. Final Report to the California Bay Delta Authority. 30 pp. (<http://loer.tamug.tamu.edu/calfed/FinalReports.htm>).
- Silverstein, M. 1978. "Yokuts: Introduction," pp. 446–447 in R. F. Heizer (ed.), California. *Handbook of North American Indians*. Volume 8, W. C. Sturtevant (gen. ed.). Washington, D.C.: Smithsonian Institution.
- Sommer, T. 2007. The Decline of Pelagic Fishes in the San Francisco Estuary: An Update. Presented to the California State Water Resources Control Board, Sacramento, CA, March 22, 2007. Available at: http://www.waterrights.ca.gov/baydelta/docs/pelagicorganism/dwr_032207sommer.pdf.
- Stevens, D. E. 1989. When do Winter-run Chinook Salmon Smolts Migrate through the Sacramento–San Joaquin Delta? Memorandum: June 19, 1989. California Department of Fish and Game. Stockton, CA.
- Swanson, C. and J. J. Cech. 1995. *Environmental Tolerances and Requirements of Delta Smelt, Hypomesus transpacificus*. Final Report, Department of Water Resources. 77 pp.

- The Bay Institute, Center for Biological Diversity and Natural Resources Defense Council. 2007. Petition to the State of California Fish and Game Commission and Supporting Information for the Listing of Delta Smelt (*Hypomesus transpacificus*) as an Endangered Species under the California Endangered Species Act. February 7.
- Thomas Brothers. 1920. California, Central. San Francisco, CA: Thomas Brothers. On file at California History Room, California State Library, Sacramento, CA.
- Thompson, J. 1957. The Settlement Geography of the Sacramento–San Joaquin Delta, California. Ph.D. dissertation, Stanford University. On file at California History Room, California State Library, Sacramento, CA.
- U.S. Department of Commerce, Bureau of Census. 2000. Demographic profiles. Available: <http://censtats.census.gov/pub/Profiles.shtml>.
- U.S. Department of Commerce, Bureau of Census. 2003. State and county quick facts, Hispanic origin. Available: http://quickfacts.census.gov/qfd/meta/long_68188.htm. Accessed February 7, 2003.
- U.S. Department of Interior, Bureau of Reclamation, Mid-Pacific Region. June 2004. *Shasta Lake Water Resources Investigation, Initial Alternatives Information Report*.
- U.S. Department of Interior, Bureau of Reclamation. 2007. Plan of Study for the North/Central Delta Improvement Study (Delta Cross Channel, Franks Tract, and Through-Delta Facility Evaluation). August.
- U.S. Fish and Wildlife Service (USFWS). Species profile for North American green sturgeon (*Acipenser medirostris*). Available online at: <http://ecos.fws.gov/speciesProfile/SpeciesReport.do?spcode=E09K>
- U.S. Fish and Wildlife Service (USFWS). 1993. *Abundance and Survival of Juvenile Chinook Salmon in the Sacramento-San Joaquin Estuary*. 1992 annual progress report. Stockton, CA.
- U.S. Fish and Wildlife Service (USFWS). 1994. *The Relationship Between Instream Flow, Adult Migration, and Spawning Habitat Availability for Fall-run Chinook Salmon in the Upper San Joaquin River, California*. Upper San Joaquin River IFIM Report, Ecological Services. Sacramento, CA.
- U.S. Fish and Wildlife Service (USFWS). 1996. *Sacramento–San Joaquin Delta Native Fishes Recovery Plan*. U.S. Fish and Wildlife Service, Portland, OR.
- U.S. Water Resources Council (WRC). 1983. Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies.

Chapter 12: References

- Vogel, D. A. 2004. *Juvenile Chinook Salmon Radio-Telemetry Studies in the Northern and Central Sacramento-San Joaquin Delta, 2002 – 2003, Final Report*. Contract report for CALFED, administered by the National Fish and Wildlife Foundation. Natural Resource Scientists, Inc. January. 188 p.
- Wagner, D. L., E. J. Bortugno, and R. D. McJunkin. 1990. Geologic Map of the San Francisco–San Jose Quadrangle. California Division of Mines and Geology. Sacramento, CA.
- Wallace, W. J. 1978. “Northern Valley Yokuts,” pp. 462–470 in R. F. Heizer, California. *Handbook of North American Indians*. Volume 8, W. C. Sturtevant (gen. ed.) Washington, D.C.: Smithsonian Institution.
- Wang, J. C. S. 1986. Fishes of the Sacramento–San Joaquin Estuary and Adjacent Waters, California: A Guide to the Early Life Histories. (FS/10-4ATR86-9.) California Department of Water Resources. Sacramento, CA. Prepared for Interagency Ecological Study Program for the Sacramento–San Joaquin Estuary, Sacramento, CA.
- Wang, J. C. S. and R. L. Brown. 1993. *Observations of Early Life Stages of Delta Smelt, Hypomesus transpacificus, in the Sacramento–San Joaquin Estuary in 1991, with a Review of its Ecological Status in 1988 to 1990*. Technical Report 35. November.
- Wheatley B. and M. Wheatley. 2000. “Methylmercury and the Health of Indigenous Peoples: A Risk Management Challenge for Physical and Social Science and for Public Health Policy.” *Sci Total Envir*.
- Wiener, J. G., D. P. Krabbenhoft, G. H. Heinz, and A. M. Scheuhammer. 2003. Ecotoxicology of Mercury, Chapter 16 in D. J. Hoffman, B. A. Rattner, G.A.

SAC/350530/100750006